VUV MACHINE

Stephen Kramer
VUV Ring Manager

Figure 1 shows the breakdown of the VUV Ring operating statistics for the Fiscal Year 1997. The monthly breakdown of most significant operational performance statistics are presented in Figures 2 through 6. The operational statistics continue to show improvement above the record year of FY 1996. The fraction of the time during the year resulting in unscheduled downtime was only 1.5%. The probability that beam was not available when it was scheduled for operations was only 2.38%. However the total beam time actually delivered to the users was 6 hours greater than was scheduled, or 100.1% of scheduled. This resulted from the early return from maintenance and a reduction in accelerator study hours actually used. The accelerator performance continued to improve with higher injection rates and longer beam lifetimes. Injections are now routinely done in less than 3 minutes with the average approaching 2 minutes. The beam lifetime had been lower due to higher vacuum resulting from the two openings of the ring during the year and due to vacuum leaks. However, from August through the end of the year the lifetime has exceeded the pre-shutdown values by about 8%. This was achieved despite the new gas load introduced by the new U12IR mirror being inserted into the ring vacuum chamber and a leak in the front-ends of two beam ports. To help reduce the impact of these new gas loads, a new beam scrubbing shift (vacuum chamber conditioning shift) was introduced during the owl shift (0:00 to 08:00) of the two day study period that occurs once a month. This shift helps desorb the gas that was introduced by these new sources more rapidly than would occur during normal operations and helps reduce the base pressure of the ring.

The major improvement to the VUV Ring during this fiscal year occurred during the winter shutdown when another large aperture beam port was installed for the U2IR beamline. The ceramic gap just after this beam chamber had started to leak during the fall 1996 and was also replaced during the winter shutdown of the ring. Despite the increased work load from the ceramic gap replacement, the effective planning of the Mechanical Group allowed the ring to be brought on four days early and scrubbing of the vacuum with beam to take place during the three day holiday weekend. This allowed operations to begin on schedule but with longer beam lifetime resulting from the reduced vacuum pressure. During the spring, a front-end valve started leaking in the half of the ring opened during the winter shutdown. This valve was replaced during the May shutdown requiring the same half of the vacuum chamber to be vented again. Recovery to pre-shutdown values of the beam lifetime required about the same integrated current as the winter shutdown, but since this vacuum work had not been anticipated, much of the beam scrubbing had to be done during operations.

Other improvements in the ring resulted from changes in the damping of higher order mode of the main RF cavity and other changes in this RF control system. Testing began on the implementation of a fast RF feedback system on the main RF system. This system should suppress the noise introduced by that RF system on the beam and it appeared to work quite well when operated by itself. However, when the bunch lengthening RF system was also working the beam showed increased fluctuations and will require more work to allow these two systems to work together. Other improvements were in the diagnostics of the electron and photon beams. New extended dynamic range Beam Position Monitor (BPM) receivers were installed on all of the ring's pickups. This will allow measurements of the beam position down to lower values of current. This of little concern for normal operating currents but will help better understand the electron beam model for the ring by allowing measurements at low beam current. A new fast turn-to-turn BPM measurement system was prototyped and the full system should be operational in FY 1998. This BPM will allow modeling of the non-linear properties of the electron beam. Other diagnostic improvements that are planned will help understand the fast beam fluctuations and how to reduce their impact on the users.

The long awaited improvement in the VUV radiation shielding did not take place during FY 1997, as it was originally planned. This was due to the difficulty in finding suppliers of the heavy concrete shielding blocks.

However, this supply difficulty has been overcome and the shielding is planned to be installed around half of the ring during the winter 1997-1998 shutdown. Once the improvement in the radiation levels in that half of the ring is measured the remainder of the shielding will be scheduled for a future shutdown. When the radiation shielding has been installed new studies of the Top-Off Method of Injection (TOMI) will be performed, in order to demonstrate that TOMI offers the users the ultimate improvement in beam stability over long time periods both from the source and the optics points of view. TOMI will also eliminate the age old conflict between longer beam lifetime and higher brightness of the photon beam. To insure that the frequent injection pulses are not seen by the users, new shorter pulse kickers will be installed in FY 1998 to allow the injected beam to be added to the stored beam with minimum disturbance to the stored beam.

During the next fiscal year studies will be carried out to increase the operating beam energy of the VUV Ring. This will continue the improvement in beam lifetime that has dominated the past improvements. In addition, studies are being carried out to develop methods of providing for real-time variation of the undulator gaps in the ring. Although this is common place on the high energy rings, the lower energy of the VUV Ring makes the impact of these gap changes more significant for the other users. The initial studies to control the orbit and betatron tunes proved insufficient and addition correction of horizontal-vertical coupling effects also will have to be compensated. ■

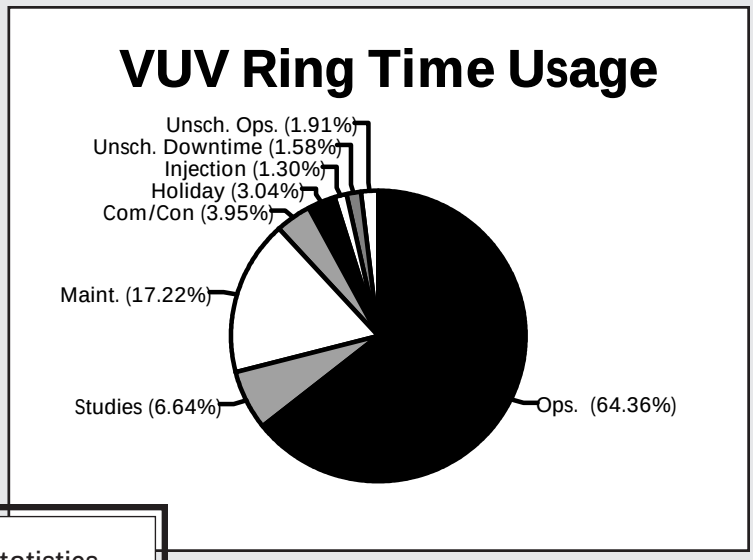


Figure 1: The breakdown of the VUV Ring usage based on total time (not scheduled time) for FY 1997.

FY 1997 Ring Performance Statistics

Ave. fill Current: 848 mA
Ave. Charge Rate: 168 mA/min
Ave. Lifetime at 500 mA: 314 min
Total user integrated current:
2980 A-Hrs (124 A-days)
Total hours of operation: 5752 hours
Average operating current: 518 mA

VUV Ring Performance

FY 1997

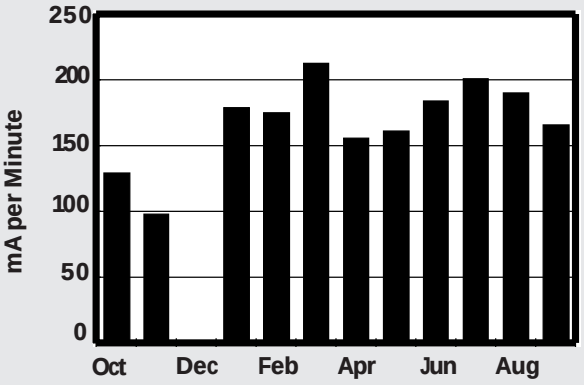


Figure 2: The VUV Ring injection charge rate average over all fills in each month.

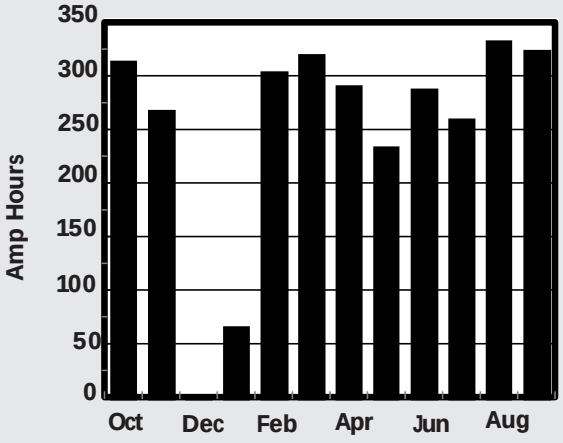


Figure 3: The total integrated current for the VUV Ring accumulated each month.

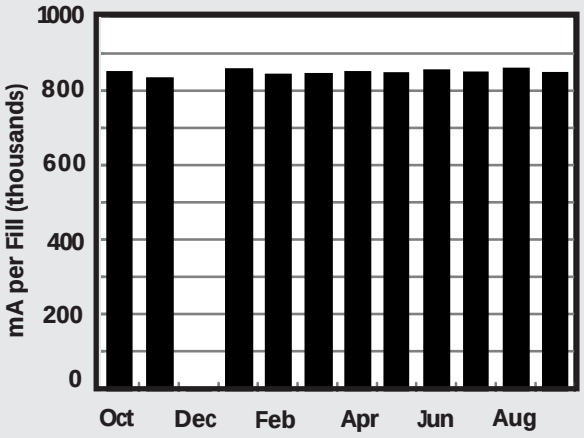


Figure 4: The injection current averaged over all fills in a month for the VUV Ring.

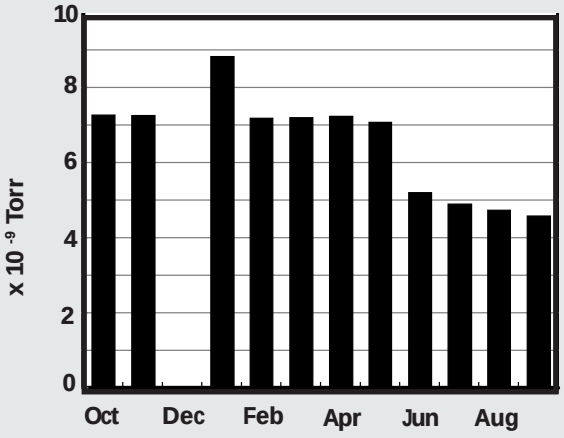


Figure 4: The VUV Ring vacuum pressure at 500 mA beam current averaged over each month.

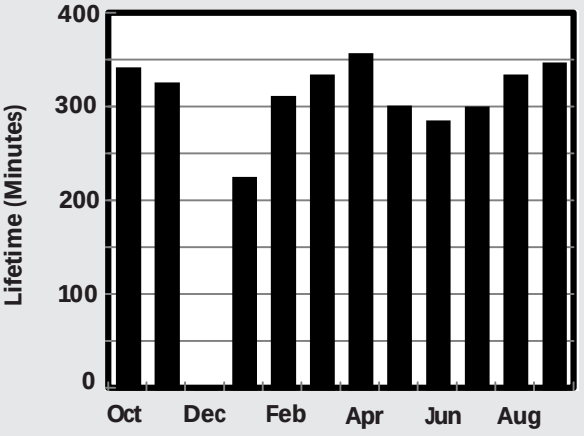


Figure 6: The VUV Ring exponential beam lifetime at 500 mA beam current (seven bunch operation only) averaged over each month.

VUV Storage Ring Parameters as of November 1997

Normal Operating Energy	0.808 GeV
Peak Operating Current (multibunch ops.)	1.0 amp (1.06 x 10^{12}e-)
Circumference	51.0 meters
Number of Beam Ports on Dipoles	17
Number of Insertion Devices	2
Maximum Length of Insertion Devices	~ 2.25 meters
$\lambda_c(E_c)$	19.9 Å (622 eV)
B(ρ)	1.41 Tesla (1.91 meters)
Electron Orbital Period	170.2 nanoseconds
Damping Times	$\tau_x=\tau_y$= 13 msec; τ_ε = 7 msec
Lifetime @ 200 mA with 52 MHz	360 min
(with 211 MHz Bunch Lengthening)	(590 min)
Lattice Structure (Chasman-Green)	Separated Function, Quad, Doublets
Number of Superperiods	4
Magnet Complement	8 Bending (1.5 meters each) 24 Quadrupole (0.3 meters each) 12 Sextupole (0.2 meters each)
Nominal Tunes (ν_x,ν_y)	3.14, 1.26
Momentum Compaction	0.0235
RF Frequency	52.886 MHz
Radiated Power	20.4 kW/amp of Beam
RF Peak Voltage with 52 MHz (with 211 MHz)	80 kV (20kV)
Design RF Power with 52 MHz (with 211 MHz)	50 kW (10 kW)
Synchrotron Tune (ν_s)	0.0018
Natural Energy Spread (σ_e/E)	5.0 x 10^{-4} , I_b< 20 mA
Bunch Length (2σ)	9.7 cm (I_b < 20 mA)
(21_{rms} with 211 MHz Bunch Lengthening)	(36 cm)
Number of RF Buckets	9
Typical Bunch Mode	7
Horizontal Damped Emittance (ε_x)	1.62 x 10^{-7}, meter-radian
Vertical Damped Emittance (ε_y)	≥ 3.5 x 10^{-10} meter-radian (2.8 x 10^{-9} in normal ops.)*
Power per Horizontal Milliradian (1A)	3.2 Watts

Arc Source Parameters

Betatron Function (β_x,β_y)	1.18 to 2.25 m, 10.26 to 14.21 m
Dispersion Function (η_x,η_x)	0.500 to 0.062 m, 0.743 to 0.093 m
$\alpha_{x,y}$ = -β' $_{x,y}$/2	-0.046 to 1.087, 3.18 to -0.96
$\gamma_{x,y}$ =(1 +$\alpha_{x,y}$)/$\beta_{x,y}$	0.738 to 0.970 m^{-1}, 1.083 to 0.135 m^{-1}
Source Size (σ_x, σ_y)	536 to 568 μm, >60 to >70 μm (170-200 μm in normal ops.)*
Source Divergence (σ_x,σ_y)	686 to 373 μrad, 19.5 to 6.9 μrad (55-20 μrad in normal ops.)*

Insertion Device Parameters

Betatron Function (β_x, β_y)	11.1 m, 5.84 m
Source Size (σ_x, σ_y)	1240 μm, >45 μm (130 μm in normal ops.)*
Source Divergence (σ_x, σ_y)	112 μrad, >7.7 μrad (22 μrad in normal ops.)*

* ε_y is adjustable

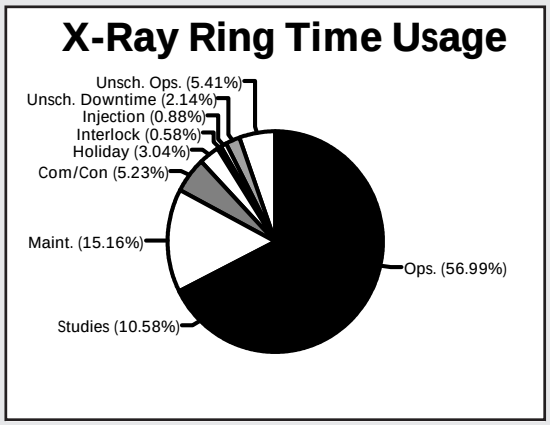
X-Ray Ring

Roger Klaffky
X-Ray Ring Manager

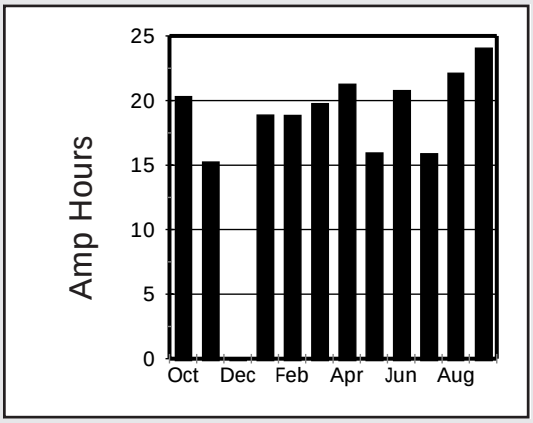
In preparation for the December 1996 shutdown, water lines were installed in Fall 1996 to bring BNL Central Chilled Water Facility (CCWF) water to the NSLS experimental water system in Mechanical Equipment Room A. The control valve/controller installation for this system began. This upgrade was designed to improve temperature regulation, with the present NSLS experimental water system providing redundancy in case the CCWF goes down for maintenance. The BNL CCWF connection to the NSLS experimental water system was completed during the December 1996 shutdown, and temperature control of this system was upgraded. To maintain a redundant NSLS cooling capability in case the CCWF goes down, the old Baltimore cooling tower was replaced and plans were made to upgrade and expand its controls. The experimental water pump capacity was increased and spigots were installed for beamlines requiring enhanced cooling.

A major effort during the December 1996 shutdown was the installation of 20 new beryllium windows to enable 350 mA operation in January 1997. New windows were installed on X3A, X4A, X6A, X12A, X12B, X12C, X13, X14A, X14B, X15A, X19C, X20A, X20C, X21, X22A, X23A, X23B, X25, X26A and X26C. Brazing and welding of the windows was done by Brush Wellman Electrofusion with the pieces being fabricated by BNL Central Shops. An additional 20 windows were also received, which included the remaining windows required for 438 mA operation and at least one spare window for each assembly type. Since the new windows had 5 mm vertical openings (as opposed to 10 mm for the old windows), commissioning shifts were provided in January 1997 to the above beamlines to confirm that the windows were properly surveyed into position.

The dual hybrid RF power amplifier was installed on RF System 2 in December 1996. Two 120 kW amplifiers are combined in this system to enable 438 mA operation and to prevent a beam dump if one of the other



The breakdown of the X-Ray Ring usage based on total time (not scheduled time) for FY 1997.



The total integrated current for the X-Ray Ring accumulated each month for FY 1997.

three RF systems drops out. After an initial commissioning period in January, the new dual transmitter on the RF2 cavity became operational. At present each of the transmitters is operating at half power (40-50 kW) with increased reliability. During the Spring 1998 shutdown, a new all-copper cavity will replace the existing copper-clad steel cavity and a new copper coupling loop brazed to a beryllia ceramic window will allow the transmission of more than 150 kW into the cavity. This additional power will enable reliable 438 mA operation at 2.584 GeV or 250 mA operation at 2.8 GeV. Improved windows for the other RF systems were ordered. The new cavity has several desirable features. There are no welded ports or joints, cooling channels are machined in the outside skin, and there is an improved mushroom cooling. The cavity was shipped to the NSLS in September 1997, after an acceptance test in Germany.

Operations commenced on the X-Ray Ring on January 23, 1997 at 350 mA. On February 1, there developed a water-to-vacuum leak in the RF1 cavity, causing the cavity pressure to jump from the 10^{-10} Torr range to the mid 10^{-07} Torr range. Helium leak detection failed to identify which water-cooled component was leaking. At an emergency user meeting the decision was made to replace the RF coupling loop, the most likely defective component, during the February 10 - 11 studies period and to continue operating at 250 mA until that time using the other three RF cavities. The repair was carried out on February 10th, followed by RF and beam conditioning on February 11th. Operations resumed on schedule at noon on February 12th. By February 15th, conditioning with operational beam had lowered the cavity pressure to the 10^{-09} Torr range.

In February 1997, an effort to fully characterize the beamline shielding requirements at 2.8 GeV commenced. Studies periods were utilized for radiation surveys by S&EP personnel to record in detail which beamline components and hutch walls require additional shielding. The initial surveys were completed in April so that users could make use of the May shutdown period to shield. A 21,000 pound shipment of (3'x5'x1/16") sheets was delivered early in May, and a work area was set up outside the NSLS Stockroom for cutting the lead sheet. Procedures for handling the lead and discarding lead scraps, contaminated covering material, gloves and aprons were outlined in the April 16, 1997 NSLS ES&H Highlights. Users were encouraged to begin their shielding efforts early because obtaining final operational approval of the shielding was, in many cases, an arduous process requiring a series of radiation surveys followed by shielding efforts. Beamline personnel continued to use dedicated studies shifts to survey the effectiveness of additional lead shielding for 2.8 GeV operation. To expedite this process, beamlines having sufficiently low radiation levels were put on a list to operate in a "self-monitoring" mode. In this mode users are able to immediately check newly-installed shielding and make required modifications. During the 2.8 GeV operations/ survey week of September 23-29,1997, the X-Ray Ring operated reliably with 230 mA fills. By the end of the week there were 34 beamlines operating in either the self-monitoring mode or in an "approved" mode after a final survey indicated that all beamline components had levels less than 500 cpm on a Ludlum pancake Geiger counter. Self-monitoring lines were expected to continue their shielding efforts to the satisfy the 500 cpm requirement.

During FY 1997 the horizontal and vertical digital feedback systems were prepared for operation. However these systems were not implemented because of a large horizontal chamber motion during a typical fill. To track the chamber motion, sensor stands will be installed and data acquired during operations from high sensitivity LVDT probes mounted on stands at various PUE locations. Carbon fiber tubes for the stands are expected to arrive in January 1998. Data acquired from the horizontal sensors measuring the ring chamber motion at each of the 48 PUEs during X-Ray fills, will be input to the digital feedback system to correct for this motion. During 1997 the algorithm of the global harmonic feedback system was changed to give a factor of two improvement in orbit stability. The programmable boards for the analog global feedback system were received. Initial studies were conducted on the low emittance lattice with the low emittance lattice response matrices successfully downloaded onto these boards. Studies of the new lattice will continue in order to check orbit stability and to increase the fill current to 440 mA.

The major X-Ray Ring task during the May 1997 shutdown was the removal of the PSGU(Prototype Small Gap Undulator) from the X13 straight and the installation of the IVUN(In-Vacuum Undulator) which is a short-period magnet array (30.5 periods, with an 11 mm period length) developed at SPring-8. The associated vacuum chamber and mechanical systems were developed at the NSLS. IVUN is designed to produce 4.6 keV radiation in the fundamental, at a magnet gap of 3.3 mm, with useful photon fluxes in both the 2nd and 3rd harmonics. The magnet gap is adjustable between 2 mm and 10 mm. A number of other shutdown tasks were completed. Upgraded beryllium windows were installed on the X4C and X6B beamlines. The remaining 13 upgraded beamline windows required for high current (438 mA) operation will be installed during maintenance periods and the December 1997 shutdown. Safety metering

transformers were installed on 480 Volt RF and magnet power supplies to verify isolation from source power before carrying out repair work. Also, the full cooling capability of the NSLS high pressure and low pressure copper water systems was restored after heat exchangers for these systems were cleaned out. Finally, the helium cryotransfer line for the X17 superconducting wiggler was replaced, allowing the X17 beamlines to resume operation on June 9th. A leaking transfer line had shut these lines down since the middle of April. Substantial improvements were made on the X17 cryogenic system. The two helium supply and return transfer lines to the refrigerator were totally rebuilt, thereby eliminating an erratic heat leak. Another major problem was solved when a metal chip was removed from the autofill valve seat to the magnet cryostat. After these repairs the system ran smoothly.

Following the installation of the IVUN (In-Vacuum UNdulator) in the X13 straight section during the May 1997 shutdown, there followed a commissioning period. Initial conditioning was carried out at a gap of 10 mm. After 10 amp-hr of conditioning the pressure at 330 mA was 7.1 nTorr which further decreased to 1 nTorr after 230 amp-hr. During studies periods, IVUN operated with magnet gaps between 10 mm and 3.2 mm. At a gap of 3.2 mm the ring lifetime decreased to about 12.7 hr, corresponding to a partial lifetime contribution of over 100 hours. The observed photon spectrum from the IVUN was measured in the X13 hutch using a single crystal spectrometer. The agreement between the observed and theoretical spectrum was good. The brightness at the peak of the 4.6 keV fundamental was $3x10^{17}$ photons/sec/0.25amp/mm^2/mrad^2 /0.1% bandwidth. Also, during FY 1997 the X13 Elliptically Polarized Wiggler (EPW) was able to operate at 2,23, and 100 Hz with the x-ray orbit compensated so that other beamlines were not affected. ■

X-Ray Storage Ring Parameters as of November 1997

Normal Operating Energy	2.584 GeV
Maximum Operating Current	0.30 amp (10^{12} e-)
Lifetime	~20 hours
Circumference	170.1 meters
Number of Beam Ports on Dipoles	30
Number of Insertion Devices	5
Maximum Length of Insertion Devices	< 4.50 meters
$\lambda_c(E_c)$ at 1.25 T (B)	2.23 Å (5.6 keV)
$\lambda_c(E_c)$ at 5.0 T (W)	0.56 Å (22.2 keV)
B(ρ)	1.25 Tesla (6.875 meters)
Electron Orbital Period	567.2 nanoseconds
Damping Times (2.584 GeV)	$\tau_x = \tau_y$ = 6 msec; τ_ε = 3 msec
Touschek (2.584 GeV, 0.25A)	≥ 27 hrs (v_{RF} = 700 kV)
Lattice Structure (Chasman-Green)	Separated Function, Quad Triplets
Number of Superperiods	8
Magnet Complement	16 Bending (2.7 meters each) 40 Quadrupole (0.45 meters each) 16 Quadrupole (0.80 meters each)
32 Sextupole	(0.20 meters each)
Nominal Tunes (ν_x,ν_y)	9.15, 6.20
Momentum Compaction	0.0056
RF Frequency	52.88 MHz
Radiated Power for Bending Magnets	144 kW/0.25 amp of Beam
RF Peak Voltage	1000 kV
Design RF Power	400 kW
ν_s (Synchrotron Tune)	0.002
Natural Energy Spread (σ_e/E)	8.6 x 10^{-4}
Natural Bunch Length (2σ)	10.5 cm
Number of RF Buckets	30
Typical Bunch Mode	25
Horizontal Damped Emittance (ε_x)	1.0 x 10^{-7}, meter-radian
Vertical Damped Emittance (ε_y)	1 x 10^{-10} meter-radian
Power per Horizontal Milliradian (0.25A)	23 Watts

Arc Source Parameters

Betatron Function (β_x,β_y)	1.0 to 3.8 m, 7.9 to 26.5 m
Dispersion Function (η_x,η_x)	0.47 to -0.11, -0.39 to 0.22
$\alpha_{x,y} = -\beta'_{x,y}/2$	-0.49 to 1.62, -3.4 to 4.5
$\gamma_{x,y} = (1 + \alpha_{x,y})/\beta_{x,y}$	0.952 to 0.962 m^{-1}, 0.81 to 0.52 m^{-1}
Source Size (σ_x, σ_y)	371 to 565 μm, 27 to 49 μm
Source Divergence (σ_x,σ_y)	439 to 324 μrad, 8 to 7 μrad

Insertion Device Parameters

Betatron Function (β_x, β_y)	1.60 m, 0.35 m
Source Divergence (σ_x, σ_y)	260 μrad, 35 μrad

Beamline Technical Improvements

Roger Klaffky
Beamline Technical Liaison

VUV BEAMLINES

There were a number of technical beamline improvements on the VUV Ring during FY 1997. Rebuilding of the U2A beamline for high-pressure infrared spectroscopy and for infrared micro-spectroscopy was underway. The U1/U2 dipole chamber chamber was modified during the winter 96-97 shutdown to provide a solid angle of 100(H) x 48(V) mradians on the U2 port. Extraction optics consisting of a new mirror box and diamond window were designed and built at the NSLS. A new Bruker IFS 66 V/s FT-IR instrument was purchased and a new Bruker II, IR microscope was tested and implemented for samples in small diamond cells. The optics in both of these instruments was modified for synchrotron radiation measurements. In addition, a new large working distance microscope was designed and built.

Beamline U3A was in an intensive recommissioning phase involving hardware upgrades, monochromator development, beamline calibration and diagnostics. Hardware modification included reconfiguration of the M0 mirror chamber, a beamline computer upgrade, installation of RF reactors for cleaning XUV optics, installation of a new filter assembly, and monochromator operations. Several sets of monochromator crystals and multilayers were mounted and aligned. These included matched pairs of beryl, Na β alumina, Mo/Si and W/Si multilayers. Harmonic content was negligible above 1000 eV. Second order harmonics above 800 eV were controlled with filters. Monochromator motors were replaced and motor translators modified to allow for a programmable holding torque.

The microscope from U2B was moved to U4IR where it was used for several experiments.

As part of the DOE Scientific Facilities Initiative (SFI) spherical gratings and a moveable exit slit will be added to the U4A beamline, replacing the present toroidal gratings and fixed slits. A computer upgrade was in progress and in the ARP chamber, a new cluster of metal evaporators and a thin film thickness monitor were installed.

The U4B SGM-based beamline optics were commissioned, as was the UHV chamber and growth capabilities. The U5UA beamline and its spin-resolved photoemission end station began full operation in January 1997.

A full General User program began at the new U7A S6M soft x-ray photoemission and spectroscopy beamline. Installation and commissioning of a high pressure surface chemistry chamber on top of the chemistry end-station took place.

The former U9A beamline was removed and plans were made to install an NSLS general machine vacuum R&D beamline to measure photon-stimulated desorption of materials and coatings for advanced UHV construction.

Two modified ring vacuum chambers were installed during the Spring 1996 shutdown to provide a 100(H) x 48(V) mradian solid angle IR beam at the U10 port and a 90(H) x 90(V) mradian solid angle IR beam at the U12IR port. The U10A beamline was under construction in FY 1997 and is intended to operate with a rapid Scan Bruker IFS 66V/s FT vacuum spectrometer over the range of 1.2 meV to 3.3 eV. The U12IR beamline was in the final stages of construction with the UHV mirror tank installed on the ring and most of the beam-transport following the diamond window complete. Two IR spectrometers were installed: a far-infrared lamellar grating interferometer for spectra between 2 and 100 cm^{-1} and a Bruker IFS 113V for the 50-10,000 cm^{-1} range.

During 1997 redesign and reconstruction of beamline U12A continued, which will result in a conversion from a TGM into a TGM/SGM beamline covering the 100-800 eV photon energy range. Upgraded electric service was installed. Optics for this conversion will arrive in 1998.

The U13UB beamline was under construction in 1997. This beamline is devoted to UV/VUV spectroscopy in the 5-30 eV range. The U13 undulator/wiggler source can be directed to either: (1) a focused white light branch, or (2) a high energy resolution monochromatic branch. The PRT members acquired DOE SFI funds to design and construct a high resolution ARPES chamber.

At U15 the beamline computer control hardware and software were upgraded as was the vacuum system. The U16B ERG monochromator and refocusing optics were restored to an operating condition.

X-RAY BEAMLINES

The X1A beamline was rebuilt during the second half of 1996 and started operation in the new configuration in February 1997. The rebuilding resulted in two independent branches, improved energy resolution and flux, and additional space. A large effort was directed towards commissioning of the cryo-scanning transmission x-ray microscope (Cryo-STXM) on the inboard branch line. This instrument images frozen hydrated biological specimens at near liquid nitrogen temperature, where radiation damage does not manifest itself even after repeated imaging. Tomography data sets were taken with this apparatus. Cryogenic capabilities were implemented in the x-ray holography chamber, which is also used on the inboard branch line.

Two new experimental facilities were implemented on X1B. A soft x-ray emission (SXE) spectrometer was commissioned as was a new spin polarization facility based on the use of a Scienta hemispherical analyzer and a micro-Mott spin polarimeter. This will allow high resolution spin polarized photoemission studies in the soft x-ray range.

At X3A electric wiring in the monochromator assembly was redesigned to eliminate cross-talk between the A1 and A2 monochromators. Also, new operating software for a Pentium PC was under development in collaboration with the staff of the 15-ID station at the APS.

On X4A a new Raxis-IV automated detector was installed and tested. The X4C beamline approached completion. First light was taken into the hutch in February 1997. The Windows 95 based VME motion control system began operation, controlling close to 30 motors. The horizontal focusing monochromator, based on an NSLS design, was commissioned. In the future, the monochromator will be completely characterized and

The New DOW / NIST Materials Characterization Facility at Beamline U7A.
Back, left to right: Arnie Moodenbaugh (DAS), James Wood (Osmic, Inc.), Raj Korde (IRD), Michael Hart (Chairman, NSLS), Gabrielle Long (NIST), Steve Hulbert, and Qing Yi Dong (NSLS).
Front, left to right: Daniel Fischer (NIST), Benjamin DeKoven (DOW), Stephen Freiman (Chief, Ceramics Division, NIST), Lyle Schwartz (Director, Materials Science & Engineering, NIST), and Robert Bubeck (Synchrotron Coordinator, DOW).

a vertical focusing mirror will be installed.

There were substantial improvements at the X5 Laser Electron Gamma Source (LEGS) beamline. The first phase of the Spin ASYmmetry detector array (SASY) was installed in the X5 experimental area. The detector array comprises the XTAL BOX (an array of Pb-glass Cerenkov counters. A prototype of the in-beam Gas Cerenkov counter for the rejector of electron pair production events online was also implemented. The XTAL BOX provides good photon resolution (~10%) for high energy photons as all azimuthal angles and at polar angles of 70 to 145 degrees in the current configuration. The forward wall of plastic scintillators provides coverage for nucleons from 10 to 35 degrees with a 40% efficiency for the detection of neutrons. The plastic bars and Pb-glass wall are capable of detecting high energy photons with moderate energy resolution, and angular resolution on the order of 6 degrees results in an overall acceptance for reconstruction of neutral pions of 50%. The complete restructuring of the X5 laser hutch was underway in order to accommodate the energy quadrupled laser designed and constructed by Frascati and BNL. This Nd-YLF ring laser delivers 2 Watts of ultra-violet light at 263 nm. The combination of the new ring laser and 2.8 GeV electrons will increase LEGS energies to 470 MeV. The development of the new spin- polarized HD ice target yielded an operable full-size target, albeit in a limited mode, of 51% H polarization and 11% D polarization. After partial aging, the target was disengaged from the dilution refrigerator, raised with the cold-transfer assembly, reinserted and the retained polarization measured. This was a milestone in the target development. The HD production equipment has been improved and operated to produce large amounts of target quality HD with only a single distillation starting from 98% pure commercial HD. The in-beam cryostat was constructed at Orsay.

At X7B it was discovered that the beamline Zerodur fused silica premirror had deteriorated due to exposure to white-beam synchrotron radiation. The beamline was reconfigured to run without a premirror while a new coated silicon crystal mirror was being manufactured for installation during the December 1997 shutdown. There was also progress in addressing monochromator heat-loading problems. Water flow to the crystal holders was improved, and graphite filters were purchased. A new MAR 345 mm image-plate based detector was purchased. Work was in progress on the design and construction of a MAR-based detector system, incorporating a precision, variable sample-to detector-distance table, a new universal sample holder installation and a new set of front-end beam positioning/tracking devices.

On the X9B beamline a MAR image plate detector and a Silicon Graphics computer were purchased to enhance the collection of protein crystallography data. Implementation of a new computer control system and monochromator modifications were also underway. Funding was secured for completion of a state-of-the-art protein crystallography station on the X9A beamline. This work will begin in FY 1998.

A number of upgrades were completed or underway on X11A, largely as a result of DOE SFI funding. A sagitally-focusing system was purchased which will provide at least a three-fold increase in intensity. A Rh-coated vertical ly collimating Si mirror was purchased for installation during the December shut down. A new Huber goniometer was purchased and a new computer-controlled slit assembly was installed in the hutch. Finally, a 13 element solid state detector was obtained.

At X12B a custom built phi-spindle was implemented for the sample goniostat. The spindle mount incorporates a high magnification video microscope. An Oxford Cryosystems Cryostream cools the sample. Funding from DOE SFI funding allowed the purchase of a large aperture Area Detector Systems Quantum-4 CCD array detector. The array generates an image consisting of 2300 x 2300 16-bit pixels, with a readout dead time of approximately 9 seconds. The detector was tested in July 1997, and has become the principal crystallography detector. A MAR scanner is used for experiments requiring greater coverage and readout dynamic range. A series of hoists and surface plates (called the “detector selector”) was installed in the hutch roof permitting rapid detector chairs. A Beowulf.Linux computational cluster was installed with a 100 MHz Ethernet connection between X12B, X12C, and X25.

The X13 port uses either the In-Vacuum Undulator (IVUN) or the Elliptically Polarized Wiggler (EPW) as a source. During FY 1997, full orbit compensation was achieved when the EPW changes the photon polarization at a 2,23, or 100 Hz rate. A soft x-ray SGM monochromator was designed and ordered for the X13A branchline using SFI funds. Commissioning will occur in 1998.

Beamline X14A initiated an upgrade of the mirror, monochromator and computer hardware. A new mirror with a factor of three lower surface roughness and insignificant figure error was procured with DOE SFI funds. The improved mirror should deliver about 25% more flux at 10 keV and a factor of 2 lower emittance at the sample. New crystals, with three times the useable surface area for focusing synchrotron radiation, will allow X14A to focus up to 15 mradians of horizontal beam divergence. X14A was designated a test-bed for the development of hardware and software to allow remote

control of major DOE facilities. Towards this end, plans were made for a migration to a PC-based computer system running SPEC, and installation of cameras and telecommunication hardware.

At X16C a front-end white-beam aperture (with slits and a pinhole) was designed and installed for microprobe and micro-XAFS applications. A permanent setup for XAFS experiments was also built.

At X17C a pair of Kirkpatrick-Baez mirrors was set up for focusing white x-ray beams at a glancing angle incidence to a 3-30 micron spot. Clean up slits were used to eliminate the tail of the focusing beam. A 130 element detector was used to permit simultaneous collection of energy dispersive x-ray diffraction at different angles, an important configuration for high pressure elastic properties studies. A new 12 degree cone double receiving slit system was developed for the multi-element detector to reduce background and increase the signal-to-noise ratio. An optical microscope for precise and convenient alignment was integrated into the diffraction system.

At the X19A a white beam damaged Zerodur mirror was replaced with a new silicon mirror. An improvement in throughput of more than a factor of 10 was achieved as well as a significant decrease in focused beam size. Additional diagnostics were installed to facilitate alignment. The successful implementation of InSb crystals took place, and the possibility of using monochromator crystals with larger d spacing to permit studies at the Al edge is under consideration. At X19C an analyzer axis was designed for the defector arm to enable harmonic contamination analysis of white beam topographs. Implementation of the axis was underway.

On the X20A,B, and C beamlines data-acquisition/analysis computers were replaced with IBM RS/6000 computers running the AIX 3.2.5 operating system. The motor controlling and data acquisition program SPEC was upgraded to version 4.03.01. A UPS for these computers, along with software capable of shutting down the AIX operating system automatically during a power outage, was purchased and installed. At X20B, a computer-controlled monochromator focus and tilt DC-motor problem was solved on the bench and plans were made to complete an X20B monochromator upgrade with the installation of these motors. At X20C a new focusing mirror purchased by the NSLS with DOE SFI funds was installed, improving the vertical focus by a factor of three. A new set of synthetic Si/W multilayers also improved the focused spot size.

Normal maintenance and upgrades were carried out at X22A,B and C including installation of a LINUX operating systems. Pt-coated Si mirrors were purchased for these beamlines using SFI funds with installation to occur in 1998. The X22B slit assembly was upgraded, and SFI funds were used to upgrade the liquid surface spectrometer, including addition of a UHV chamber for liquid metals.

The X23A2 beamline was upgraded with the installation of new ion chambers, a new Macintosh Power PC 8600/200, LABVIEW data acquisition software and a computer driven exit slit. The two-reflection Bense-Hart-type SAXS at X23A3 was temporarily replaced with a four-reflection instrument. Significant reductions in background, and concurrent improvements in signal-to-noise, were observed. Testing of the instrument continues.

At X23B it was discovered that the collimating mirror was not coated with Pt as requested. Investigation into this problem led to the discovery that several mirrors at the NSLS has been mis-coated (sometimes with germanium, rather than platinum). In May 1997 a properly coated mirror was installed resulting in a dramatic increase in flux. The monochromator microstepper controller was replaced to reduce maintenance and correct a problem with missing steps. PZT drivers were added to allow realtime adjustment of chi and a larger theta range. Computer equipment was also upgraded.

There were substantial changes at X24A as new applications using the x-ray standing wave (XSW) technique were added to the previous soft x-ray gas spectroscopy capability. New UHV chambers were made available for back-reflection XSW. DOE SFI funds were used to purchase a hemispherical analyzer for electron spectroscopy. The computer controlling the monochromator was replaced with a PC operating in LINUX or Windows. New two-axis (theta and chi) PZT correctors were installed on several monochromator crystal pairs. This will stabilize the focused beam position. Also, an InSb/KDP crystal pair was added to permit operation down to 1800 eV with a resolution of 0.5 eV or better.

At X25 SFI funds were used to purchase a new 34.5 cm diameter imaging plate system for macromolecular crystallography, and diffraction cryostats for materials and condensed matter x-ray scattering and spectroscopy applications. A new pair of monochromator multilayers was obtained and utilized in several experiments.

During FY 1997 the X-ray Computed Microtomography apparatus was moved from X27C to X27A. A multilayer monochromator was installed inside the X27A hutch to allow microtomography on biological samples in the 4 to 12 keV range. A new cooled CCD camera was integrated into the setup, increasing both the resolution and the size of samples that can be analyzed. The size of data sets that can be acquired grew due to new data collection hardware and software, and the reconstruction time reduced through the use of 8

multiplexed Pentium processors in BNL CCD. In January the newly established Advanced Polymers PRT was given approval to instrument and operate X27C for real time simultaneous small and wide angle X-ray scattering (SWAX) experiments. During the commissioning phase a double-multilayer (silicon/tungsten) monochromator, a three pin-hole SAXS collimation system, and a simultaneous SAXS/WAXD camera were installed. The double-multilayer monochromator increased the x-ray flux by a factor of 10 compared to a conventional double-crystal monochromator. The beamline began initial operations in July.

The x-ray pinhole camera on X28C continued to report data to the Control Room and history programs on a real-time basis. Cooling for stepping motor operation, and a host of signal and pre-amp cables were wired for use. Some components and features of the pinhole camera system were also improved. ■