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Informal Report

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NATIONAL SYNCHROTRON LIGHT SOURCE

USERS MANUAL:

GUIDE TO THE VUV AND X-RAY BEAM LINES

Written and
Edited by:

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August 1987

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DISCLAIMER

FOREWORD

The success of the National Synchrotron Light Source in the years to come will be based, in large part, on the size of the users community and the diversity of the scientific disciplines represented by these users. In order to promote this philosophy, the **NSLS Users Manual: Guide to the VUV and X-Ray Beam Lines**, is being published.

This manual serves a number of purposes. In an effort to attract new research, it will present to the scientific community-at-large the current and projected architecture and capabilities of the various VUV and X-ray beam lines. We anticipate that this publication will be updated periodically in order to keep pace with the constant changes at the NSLS.

The editors of this document wish to thank the numerous PRT, IDT and NSLS personnel whose efforts have made this manual possible. A companion document, the **NSLS Users Manual: Guide to Facilities at BNL and the NSLS**, will soon be available.

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Tables

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A. General Information

The following items are detailed in this section:

- an overall floor plan of the NSLS facility is given in Figure 1;
- a summary of the research areas covered by the various beam lines is given in Table 1;
- a plot showing the energy range vs. flux of the VUV and X-ray arc sources as well as five insertion devices is given in Figure 2;
- a listing of institutions currently participating in PRT's and IDT's is given in Table 2

The reader will note that all of the beam line descriptions in Sections B and C are dated. The reason behind this is that beam line configurations are constantly changing. Potential users should not necessarily assume that the beam line they are interested in corresponds exactly to the description given in this manual. They should contact the beam line Spokespersons or Local Contacts for further in-depth information. An on-going effort will be maintained by the editors of this manual to up-date the various beam line descriptions as necessary. Beam line personnel wishing to correct or up-date the descriptions contained in this manual should contact:

Nicholas F. Gmür
Experimental Program Support Section
National Synchrotron Light Source
Building 510E
Brookhaven National Laboratory
Upton, NY 11973
(516)282-2490

Individuals wishing to avail themselves of the facilities at the NSLS should contact:

Susan White-DePace
User Administrator
National Synchrotron Light Source
Building 725B
Brookhaven National Laboratory
Upton, NY 11973
(516)282-7114

A Word on the Writing of Beam Line Descriptions

Great care was exercised to ensure the accuracy and the up-to-date nature of the information presented in each of the beam line descriptions. The writing of the descriptions was a strongly collaborative effort. In the great majority of cases, Nicholas Gmür and an appropriate member of each PRT/IDT met in person and drafted the initial version of the beam line description. The remaining drafts were executed over the telephone or through the mail. Emphasis was placed on succinctness as well as on uniformity of presentation and terminology. Also encouraged was the need to demonstrate the unique qualities of each beam line. The draft was typed and circulated among the NSLS staff for proofing purposes. A final version was then sent to the PRT/IDT. Signed and dated approval was required from "the appropriate beam line authority". At this time the description was accepted for inclusion in this **NSLS Users Manual**.

The authors of this manual wish to extend their sincere thanks to all the beam line personnel without whose cooperation this manual would not be the excellent source of information it has become.

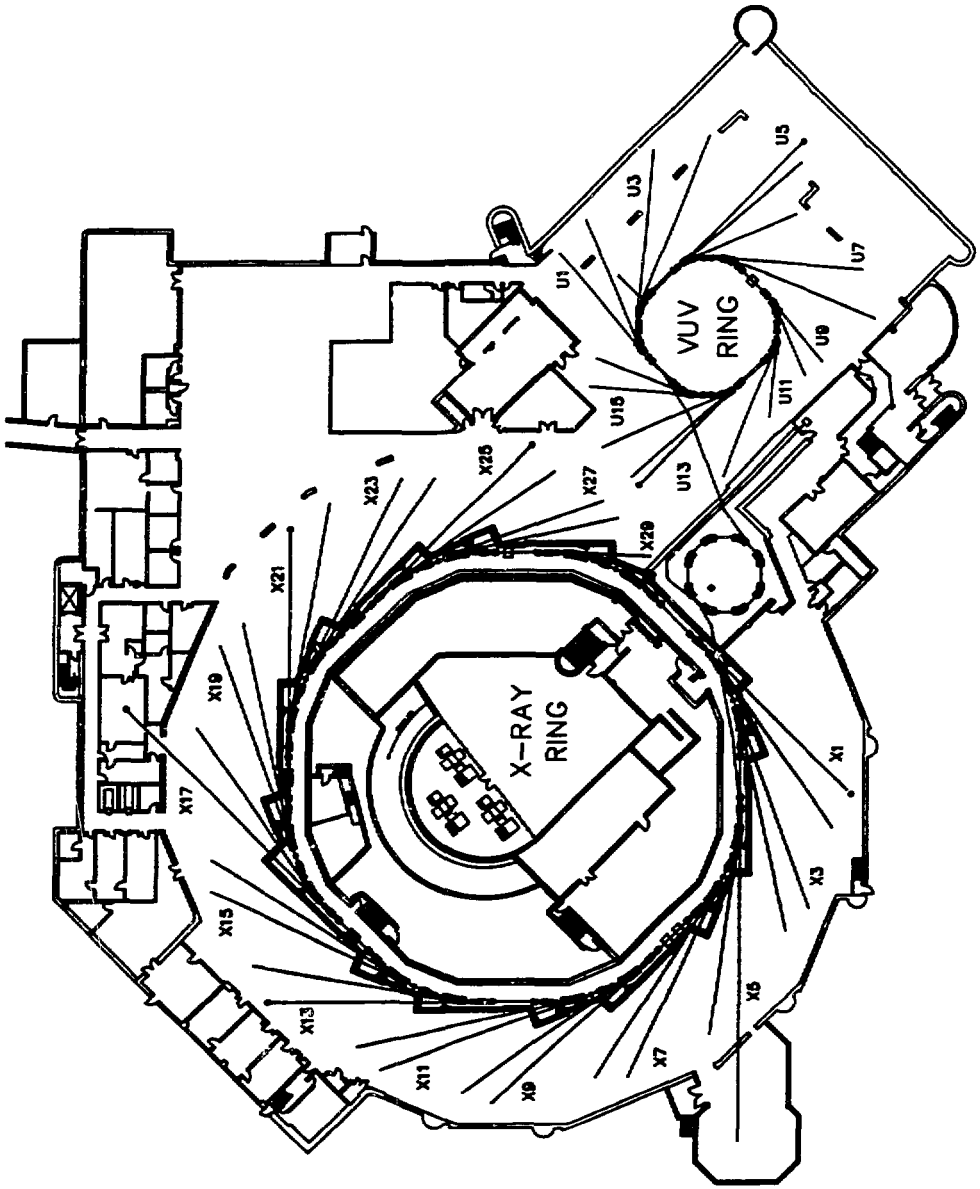

Figure 1. Floor plan of the National Synchrotron Light Source experimental area.

Table 1

Primary Research Areas of VUV and X-Ray Beam Lines

Circular Dichroism:	U9B
Energy Dispersive Diffraction:	X7A, X17C, X23A3
EXAFS/NEXAFS/SEXAFS:	U1A, U4A, U4B, U7A, U7B, U8A, U8B, U10A, U14A, U16A, X8C, X9A, X10C, X11A, X11B, X15B, X17B1, X18B, X19A, X20A, X20C, X23A2, X23A3, X23B
Gas Phase Spectroscopy/Atomic Physics:	X24A, X26A, X26C
Infrared Spectroscopy:	U4IR, U12C
Lithography/Microscopy/ Tomography:	U6, U8D, U15, X1A, X6A, X15A
Medical Research:	X17B2
Nuclear Physics:	X5
Photoionization:	U9A, U11, X8A, X26A, X26C
Radiometry:	U3B
Reflectometry:	U8C
Research & Development/ Diagnostics:	U3A, U5, U10B, U13, U14B, X12A, X13, X27, X28, X29, X30
Time Resolved Fluorescence:	U9A, U9B
Topography:	X17B1, X19C, X23A3
Transverse Optical Klystron:	U13TOK
VUV/X-Ray Photoemission Spectroscopy:	U1A, U3C, U4A, U4B, U5U, U7A, U7B, U8A, U8B, U10A, U12A, U12B, U13U, U14A, U15, U16A, U16B, U16C, X1B, X2B, X3A2, X3B, X14A, X15A, X19A, X24A, X24C
X-Ray Crystallography:	X3A1, X3A2, X7B, X10A, X10B, X12C, X14A, X17B1, X23B
X-Ray Fluorescence:	U10A
X-Ray Scattering/Diffraction:	X2A, X3A1, X3A2, X4A, X4C, X7B, X8A, X8C, X9B, X10A, X10B, X12B, X14A, X16A, X16B, X16C, X17B1, X18A, X20A, X20B, X20C, X21, X22B, X22C, X23B, X25

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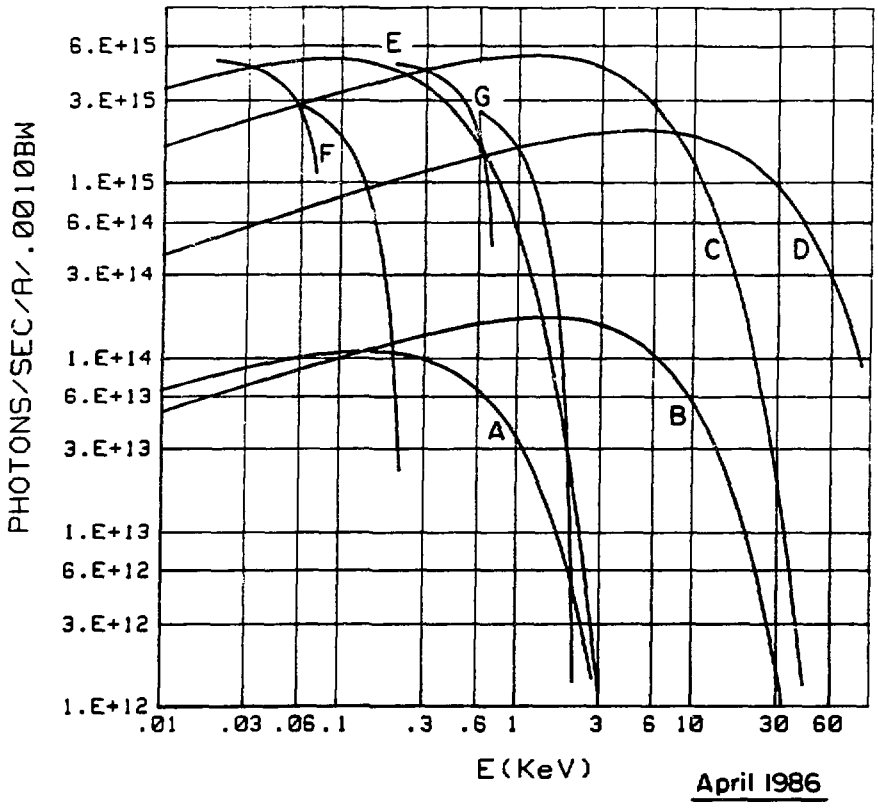


A	VUV Bend	6.5 horizontal milliradians
B	X-Ray Bend	3 horizontal milliradians
C	X21/X25	3 horizontal milliradians ($= 1.2\ K/\gamma$)
D	X17	5 horizontal milliradians
E	U13TOK	6.5 horizontal milliradians ($= 1.2\ K/\gamma$)
F	U5U	Undulator 1st, 3rd harmonics K = 0.5 to 2.5
G	X1	Undulator 1st, 3rd harmonics K = 0.3 to 2.3

For ease of comparison, the values for horizontal milliradians chosen for the VUV and X-ray bending magnets correspond to the TOK and X25 wiggler 1.2 K/γ values, respectively. For the U5U and X1 undulators the curves correspond to the flux for the first and third harmonics as K is varied (data provided by Jerome Hastings, NSLS).

Figure 2. Energy ranges of VUV and X-Ray bending magnets and insertion devices.

Table 2

Institutions Currently Participating in PRTs and IDTs at the NSLS

Universities

Alfred University
Boston University
Brandeis University
Brooklyn College of the CUNY
California State College
at Fullerton
Carnegie Institute (Washington)
Columbia University
(Howard Hughes Medical Institute)
Cornell University
Drexel University
Fairleigh Dickinson University
Georgia Institute of Technology
Harvard University
Institute for Structural and
Functional Studies
Iowa State University
Johns Hopkins University
Massachusetts Institute of Technology
Montana State University
North Carolina State University
Northwestern University
Notre Dame University
Purdue University
Stanford University
State University of New York
Texas A&M University
Universities of:
California
Chicago
Connecticut
Hawaii
Illinois
Michigan
Missouri
New Mexico
Pennsylvania
Pittsburgh
Tennessee
Texas
Washington
Wisconsin
West Virginia State University
Yale University

Corporations

Allied-Signal
AT&T Bell Labs
Celanese
Chevron
Dupont
Exxon
GTE
IBM
Mobil
Standard Oil
Union Carbide

Government Institutions

Argonne National Laboratory
Brookhaven National Laboratory
Lawrence Berkeley Laboratory
Lawrence Livermore Laboratory
Los Alamos National Laboratory
National Bureau of Standards
National Institutes of Health
Naval Research Laboratory
Oak Ridge National Laboratory
Oak Ridge Associated Universities
Sandia National Laboratory
Stanford Synchrotron Radiation
Laboratory
Superconducting Super Collider
Swedish Research Council

Based on information available at time of publication.

August 1987

B. The Vacuum Ultraviolet (VUV) Storage Ring and Beam Lines

The following items are detailed in this section:

- a list of parameters describing the VUV ring (see Table 3);
- a plot indicating the energy ranges used in the research at the various VUV beam lines (see Figure 3);
- single page descriptions for each of the VUV beam lines.

Further information regarding the VUV ring and associated beam lines may be obtained by contacting:

Dr. Richard F. Garrett
VUV Research Operations Manager
National Synchrotron Light Source
Building 510E
Brookhaven National Laboratory
Upton, NY 11973
(516)282-4245

VUV Beam Line Descriptions

Each beam line description is dated to indicate when the configuration described existed. These configurations are expected to change over time. A number of other points are explained below.

1. Operational Status:
   a. Operational - beam line is actively used in research;
   b. Commissioning - beam line is built but is being run for the sole purpose of detecting flaws in the configuration;
   c. Construction - beam line is being assembled;
   d. Planned - beam line design is completed but construction has not yet begun;
   e. Conceptual - pre-design stage.
2. Local Contact: individual(s) usually available at the beam line, their telephone number and the location of that number.
3. Spokesperson: individual(s) responsible for the beam line research program, their telephone number and the location of that number.
4. Research Program: describes only broad or general categories of research; specifics should be discussed with the beam line personnel.
5. Optical Configuration: listed in the order in which components appear going downstream along the beam line.
6. Experimental Apparatus: equipment normally available to outside users.
7. Computer System Hardware and Software: equipment normally available to outside users.
8. The following VUV beam lines are not described in this section and are used for NSLS R&D as well as for beam line diagnostics: U5A, U13A, U14B.
9. Abbreviations: ARUPS = angle-resolved ultraviolet photoemission spectroscopy; NEXAFS = near-edge extended x-ray absorption fine structure; SEXAFS = surface EXAFS; XPS = x-ray photoemission spectroscopy.

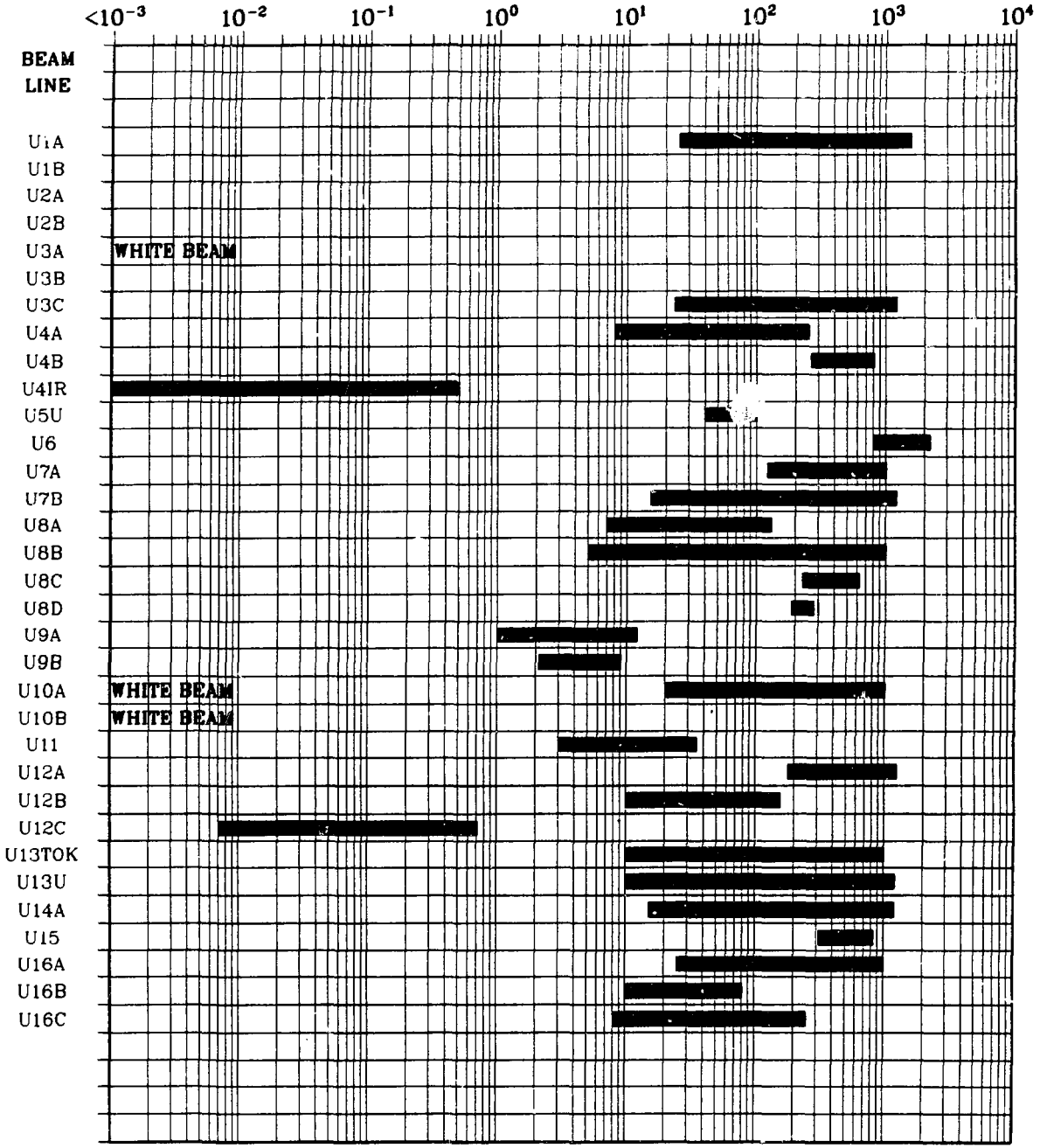
Table 3

VUV Storage Ring Parameters as of June 1987

Parameters	VUV Storage Ring
Normal Operating Energy	0.750 GeV
Design Current (multibunch operation)	1.0 amp (1.1×10^{12} e^-)
Circumference	51.0 meters
Number of Beam Ports on Dipoles	17
Number of Insertion Devices	2
Maximum Length of Insertion Devices	~3.00 meters
$\lambda_c(E_c)$	25.3 Å (486 eV)
$B(\rho)$	1.28 Tesla (1.91 meters)
Electron Orbital Period	170.2 nanoseconds
Damping Times	$\tau_x \simeq \tau_y \simeq 17$ msec; $\tau_\epsilon \simeq 9$ msec
Touschek lifetime dependent on current/bunch and vertical emittance	
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	3.12, 1.17
Momentum Compaction	0.023
R.F. Frequency	52.887 MHz
Radiated Power	14.7 kW/amp of Beam
R.F. Peak Voltage	100 kV
Design R.F. Power	50 kW
ν_s (Synchrotron Tune)	0.002
Natural Energy Spread (σ_ϵ/E)	4.5×10^{-4}
Natural Bunch Length (2σ)	7.6 cm ($I < 20$ mA)
Horizontal Damped Emittance (ϵ_x)	1.5×10^{-7} meter-radian
Vertical Damped Emittance (ϵ_y)	$\geq 2.8 \times 10^{-10}$ meter-radian (adjust.)
Power per Horizontal milliradian, 1A	2.3 Watts
Source Size: σ_h, σ_v	0.5 mm, > 0.06 mm

Source of Data: NSLS Parameters, January 1983, compiled by A. van Steenbergen; updated values provided by Gaetano Vignola (NSLS).

Figure 3: Vacuum Ultraviolet Beam Line Energy Ranges (eV)



August 1987

Beam Line:	U1A
Ring:	VUV
Operational Status:	Operational

Participating Institutions: Exxon Research and Engineering

Local Contact: Dale Sondericker (516)282-5501, 4983; BNL

Spokesperson: Wolfgang Eberhardt (201)730-2567; Exxon

Research Program: SEXAFS, ARUPS, XPS

Spectral Range (Å)	Grating Type (grooves/mm)	Grating Radius (m)	Resolution ($\Delta\lambda$ in Å)	Spot Size (mm)	Total Angular Acceptance (mradians)
8-46	1200	5	<0.024	2.0H x 1.0V	15.0H x 1.0V
8-89	800	3.71	<0.05	2.0H x 1.0V	15.0H x 1.0V
65-500	600	2	$\sim<0.09$	2.0H x 1.0V	15.0H x 1.0V

Optical Configuration

a) **M0 Mirror**
Bent flat Zerodur mirror coated with 1000 Å of platinum, horizontal collection of beam; 3° angle of incidence; located 2.8 meters from source.

b) **Monochromator**
Extended range grasshopper monochromator, scans in accordance to Rowland circle geometry; consists of a gold-coated bent elliptical mirror, a Codling mirror/entrance slit combination, three spherical gold-coated gratings interchangeable in situ in UHV, and an exit slit; the entrance and exit slits allow adjustment of monochromator resolution independent of beam source size; exit slit located 5.6 meters from source.

c) **Refocusing Mirror**
Bent cylindrical aluminum mirror coated with electroless nickel and 1000 Å of gold, horizontal and vertical focusing of beam; 2.5° angle of incidence; located 5.8 meters from source.

Experimental Apparatus

Ultra-high vacuum sample chamber configured for photoemission and surface characterization experiments; additional system exists for gas-phase spectroscopy experiments.

Computer System Hardware and Software

Menu-driven data acquisition and analysis software implemented on a PDP 11/24 computer with an RSX-11M operating system; 1 MB RAM and dual RL02 disk drive; VT100 terminal; DECwriter III terminal; Selanar 100 graphics terminal; HP plotter; NIM bin: CAMAC crate with DCC-11 Standard Engineering controller.

April 28, 1987

Beam Line:	U1B
Ring:	VUV
Operational Status:	Conceptual Operational by ____

Participating Institutions: Exxon Research and Engineering

Local Contact: Michael Sansone (516)282-5501, 5759; BNL (201)730-3388; Exxon

Spokesperson: Wolfgang Eberhardt (201)730-2567; Exxon

Research Prógram:

Monochromator

Toroidal grating monochromator.

NO DETAILS CURRENTLY AVAILABLE

April 28, 1987

Beam Line:	U2A
Ring:	VUV
Operational Status:	Unassigned

August 5, 1987

Beam Line:	U2B
Ring:	VUV
Operational Status:	Unassigned

August 5, 1987

Beam Line:	U3A
Ring:	VUV
Operational Status:	Operational

Participating Institutions: Los Alamos National Laboratory, Sandia National Laboratory, U. of California, Lawrence Livermore Laboratory

Local Contact: Randy Alkire (516)282-5503; BNL

Spokesperson: Walter Trela/Roger Bartlett (505)667-1674; Los Alamos National Laboratory

Research Program: Detector calibration

Energy Range (eV)	Grating Type (grooves/mm)	Grating Radius of Curvature (m)	Resolution ($\Delta\lambda$ in Å)	Flux (phot./sec.)	Total Horizontal Angular Acceptance (mradians)
White Beam	—	—	—	White Beam	10

Optical Configuration

a) **Mirror (M_o)**
Bent flat float glass mirror coated with platinum, collects 10 mradians horizontal fan of radiation and focuses with 1:1 magnification at monochromator exit slit (S_2); no vertical focusing; 2° grazing angle of incidence; differential pumping section; located 3.3 meters from source.

Experimental Apparatus

Oscilloscope; photodiodes; sample chamber allowing positioning of samples at focusing point of M_o mirror.

Computer System Hardware and Software

None directly associated with this beam line.

April 10, 1987

Beam Line:	U3B
Ring:	VUV
Operational Status:	Conceptual Stage Operational by ____

Participating Institutions:	Los Alamos National Laboratory, Sandia National Laboratory, U. of California, Lawrence Livermore Laboratory
Local Contact:	Randy Alkire (516)282-5503; BNL
Spokesperson:	Walter Trela/Roger Bartlett (505)667-1674; Los Alamos National Laboratory
Research Program:	Radiometry

NO DETAILS ARE CURRENTLY AVAILABLE.

April 10, 1987

Beam Line:	U3C
Ring:	VUV
Operational Status:	Operational

Participating Institutions: Los Alamos National Laboratory, Sandia National Laboratory, U. of California, Lawrence Livermore Laboratory

Local Contact: Randy Alkire (516)282-5503; BNL

Spokesperson: Walter Trela/Roger Bartlett (505)667-1674; Los Alamos National Laboratory

Research Program: Soft x-ray spectroscopy

Energy Range (eV)	Grating Type (grooves/mm)	Grating Radius of Curvature (m)	Resolution* ($\Delta\lambda$ in Å)	Flux* (phot./sec.)	Total Horizontal Angular Acceptance (mradians)
23 - 295	900	2	0.060	1×10^{10}	10
180 - 1000	1200	3.7	0.024	1×10^{10}	10
280 - 1200	1200	5	0.018	1×10^{10}	10

*for 10 μm slits

Optical Configuration

a) **Mirror (M_0)**
Bent flat float glass mirror coated with platinum, collects horizontal fan of radiation and focuses with 1:1 magnification at monochromator exit slit (S_2); 2° grazing angle of incidence; located 3.3 meters from source.

b) **Monochromator**
Extended range grasshopper monochromator, fixed exit geometry.

1) **Mirror (M_1)**
Gold coated bent elliptical mirror, collects 1 mradian (vertical) of radiation and focuses at entrance slit (S_1) with 7:1 demagnification; 1° grazing angle of incidence; located 5.5 meters from source.

2) **Mirror/Slit (M_2/S_1)**
Codling mirror/slit combination which directs beam onto one of three gratings; located 6.0 meters from source.

3) **Gratings**
Three interchangeable (in situ in UHV) spherical gold coated glass gratings available, holographically formed and ion etched; located 6.1 meters from source.

c) **Mirror (M_3)**
Gold coated bent cylinder refocusing glass mirror, integrated adjustment of focal point and spotsize to accomodate various beam line geometries; located 7.5 meters from source.

Experimental Apparatus

Surface science and atomic/molecular spectroscopy equipment.

Computer System Hardware and Software

Micro-VAXII computer using VAX/VMS operating system with CAMAC modules for beam line automation and data analysis.

Reference

Hulbert, S.E., J.P. Stott, F.C. Brown. 1983. An Extended Range Soft X-ray Beam Line for the 1 GeV Storage Ring Alladin. Nucl. Instr. and Meth. 208 : 43-47.

April 10, 1987

Beam Line:	U4A
Ring:	VUV
Operational Status:	Operational

Participating Institutions: AT&T Bell Labs

Local Contact: Jack Rowe (516)282-5504; BNL

Spokesperson: Jack Rowe (201)582-5878; AT&T Bell Labs

Research Program: ARUPS of solids and surfaces, high resolution core-level photoemission, total yield absorption

Energy Range (eV)	Grating Type (grooves/mm)	Resolution ($\Delta\lambda/\lambda$)	Flux (phot./sec. @ 0.1% bw)	Spot Size - focused (mm)	Total Angular Acceptance (mradians)
50 - 250	2400 (G1)	1×10^{-3}	0.43×10^{10} (250 mA/750 MeV)	2.0H x 0.5V	22.5H x 6.0V
20 - 100	822 (G2)	1×10^{-3}	1.7×10^{10} (250 mA/750 MeV)	2.0H x 0.5V	22.5H x 6.0V
8 - 40	288 (G3)	1×10^{-3}	1.7×10^{10} (250 mA/750 MeV)	2.0H x 0.5V	22.5H x 6.0V

Optical Configuration

a) **Mirror No. 1**
Gold coated fused quartz ellipsoidal mirror; 51 mm x 152 mm x 18 mm deep; operates at UHV; images 3135 mm downstream from mirror, magnifies by 1.5; 4.27° grazing angle of incidence; adjustable with three point linear (0.01 mm increments) and one rotational (1 mradian increments) mounts about vertical axis; located 2015 mm from the source.

b) **Monochromator**
Six meter toroidal grating monochromator with three grating types interchangeable in UHV under normal operating conditions; entrance and exit Brookhaven-design slits adjustable from 20-1500 μm; zero order angle of incidence is 80° for all gratings; gratings are aberration compensated holographic quartz type, G1 is platinum coated, G2 + G3 are gold plated; located 7 meters from the source.

c) **Mirror No. 2**
Gold coated fused quartz ellipsoidal mirror; 76 mm x 102 mm x 18 mm deep; input focal length of 1800 mm from monochromator exit; focus to sample position 0.6 meters downstream; grazing angle of incidence is 5.8°; same adjustments as Mirror No. 1; located 12.5 meters from the source.

Experimental Apparatus

The standard configuration available to outside user groups is a focused monochromatic photon beam coupled to the user group's own sample chamber; flange to sample distance is 363 mm; flange is 114.3 mm (4.5") OD conflat flange. Individual users may be given access to either a high resolution ARUPS system or a core level system; specific details of the apparatus available may be obtained from the beam line personnel.

Computer System Hardware and Software

AT&T PC6300 computer, 32 MB hard disk, 360K floppy with UNIX software; HP7475A graphics plotter; Klinger Stepper Motor Controller with both IEEE-488 interface and RS232 interface.

April 27, 1987

Beam Line:	U4B
Ring:	VUV
Operational Status:	Construction Operational in 88

Participating Institutions: AT&T Bell Labs

Local Contact: C.T. Chen (516)282-5504; BNL
Francesco Sette (516)282-5504; BNL

Spokesperson: Francesco Sette (201)582-3351; Bell Labs
C.T. Chen (201)582-6030; Bell Labs

Research Program: Soft x-ray photoemission spectroscopy, NEXAFS, SEXAFS

Expected Values					
Energy Range (eV)	Grating Type (grooves/mm)	Resolution ($\lambda/\Delta\lambda$)	Flux (phot./sec./ A/0.1% bw)	Spot Size (mm)	Total Angular Acceptance (mradians)
260 - 800	800	~3000 - 5000	4×10^{11}	3H (focused) 3V (unfocused)	15H x 1.5V

Optical Configuration

Monochromator

A spherical version of the cylindrical element monochromator (CEM) design. This monochromator employs two spherical mirrors and a spherical grating.

a) **Horizontally Focusing Mirror (HFM)**
Spherical gold coated Zerodur mirror; focuses source horizontally at the sample position (14.8 meters from source); incident angle is 87°; located 3.2 meters from the source.

b) **Vertically Focusing Mirror (VFM)**
Spherical gold coated Zerodur mirror; focuses the source vertically onto the entrance slit of the monochromator (located 2.5 meters from VFM); incident angle is 87.5°; located 3.84 meters from the source.

c) **Grating**
Spherical grating made of diffuse silica coated with gold; laminar type; diffracts and focuses vertically onto the moveable exit slit of the monochromator; the wavelength scanning mechanism is a simple sine drive type; zero order incident angle is 87°; located 10.6 meters from the source.

d) **Refocusing Optics**
Under consideration.

Experimental Apparatus

Information not available at this time.

Computer System Hardware and Software

Information not available at this time.

May 29, 1987

Beam Line:	U4IR
Ring:	VUV
Operational Status:	Commissioning

Participating Institutions: NSLS, AT&T Bell Labs, Exxon, Farleigh Dickinson U.

Local Contact: Gwyn Williams (516)282-3634, 7529; BNL

Spokesperson: Gwyn Williams

Research Program: Vibrational spectroscopy of molecules on surfaces, absorption of high T_c superconductors, fast detectors

Expected Values					
Wavelength Range (cm^{-1})	Instrument	Resolution (cm^{-1})	Brightness - compared to a black body	Spot Size - f10 diffraction limited (cm)	Total Angular Acceptance (mradians)
10 - 4000	Michelson Interferometer	0.2	100 - 1000	0.13H x 0.13V	90H x 90V
1 - 20	Scanning Laminar Grating		1000	1.0H x 1.0V	90H x 90V

Optical Configuration

Mirror System

Water-cooled silicon carbide beam extraction; beam is steered and focused by a combination of ellipsoidal and planar mirrors to provide a 1:1 image of the source on a platform on the mezzanine floor above beam lines U1, U2 and U3. Beam passes through an interchangeable window (UHV up to this point) and continues through rough vacuum into the instrumentation listed in the above table.

Experimental Apparatus

UHV surface science chamber and absorption cell.

Computer System Hardware and Software

Interferometer controlled by a dedicated data acquisition system for fast Fourier transforms, etc. Laminar grating instrumentation run by an IBM PC.

April 24, 1987

Beam Line:	U5U
Ring:	VUV
Operational Status:	Operational

Insertion Device Team: Brookhaven National Laboratory - Physics Department
Local Contact: Peter Johnson (516)282-3705; BNL
Spokesperson: Peter Johnson
Research Program: Spin polarized angle-resolved ultraviolet photoemission

Energy Range (eV)	Source	Grating Type (grooves/mm)	Included Angle (degrees)	Resolution ($\Delta E/E$)	Flux (phot./sec./ A/0.1% bw)	Total Horizontal Angular Acceptance (mradians)
40 - 100	VUV Undulator - 19 periods - 6.5 cm per.	1200	150°	2×10^{-3}	10^{14}	1

Optical Configuration

a) **Mirror No. 1**
Planar copper mirror, uncoated, directs beam toward second mirror; angle of incidence is 9°; located 8 meters from center of undulator.

b) **Mirror No. 2**
Paraboloid aluminum focusing mirror coated with electroless nickel and over-coated with gold, focuses beam onto entrance slit of monochromator; angle of incidence is 6°; located 8.25 meters from center of undulator.

c) **Monochromator**
Miniature toroidal grating monochromator with input and output slits; no exit optics; located 9.5 meters from center of undulator.

Experimental Apparatus

Surface science chamber located 10 meters from center of undulator; LEED/Auger and spin polarized angle resolved photoemission facilities.

Computer System Hardware and Software

IBM PC/XT driving CAMAC interface crate.

April 13, 1987

Beam Line:	U6
Ring:	VUV
Operational Status:	Operational

Participating Institutions: IBM - T.J. Watson Research Center

Local Contact: Jerry Silverman (516)282-5506; BNL
John Warlaumont (914)945-1819; IBM

Spokesperson: Alan Wilson (914)945-2759; IBM

Research Program: Lithography

Energy Range (eV)	Grating Type	Flux ($mW/cm^2/mA$)	Beam Size (mm)	Total Angular Acceptance (mradians)
800 - 2200	White Beam	$\geq$0.05 - integrated over energy range - dependent on area illuminated	$\leq$40.0H x 40.0V - time average uniformly illuminated area - uniformity $> \pm 10\%$	20.0H x 1.0V

Optical Configuration

a) **Mirror**
Glass gold coated cylindrical collimating mirror for increasing flux at sample by 3x; mirror scans beam at 20 Hz; angle of incidence is 24 $\pm$ 3 mradians; located 2.7 meters from the source.

b) **Beryllium Window**
Used to separate UHV beam line from downstream exposure chamber; 18 μm thick; allows up to 50 Torr in exposure chamber; located 8.5 meters from the source.

Experimental Apparatus

Exposure chamber allowing entry of samples 178 x 178 x 178 mm^3 maximum size, however, useful sample size is smaller; conflat ports are available for feed-throughs; linear motion feed-through available; pump-down time for chamber is $\sim$1 minute.

Computer System Hardware and Software

Dedicated IBM PC computer monitors and controls operation of whole beam line including exposure chamber but excepting mirror motion.

April 23, 1987

Beam Line:	U7A
Ring:	VUV
Operational Status:	Commissioning Operational Fall 87

Participating Institutions: BNL - Physics Department, NSLS, Exxon

Local Contact: Francis Loeb (516)282-5507, 2092; BNL

Spokesperson: Myron Strongin (516)282-3763; BNL

Research Program: XPS and SEXAFS on solids

Expected Values					
Energy Range (eV)	Grating Type (grooves/mm)	Resolution ($\Delta E/E$)	Flux (photons/sec.)	Spot Size - unfocused (mm)	Total Horizontal Angular Acceptance (mradians)
300 - 1000	1000	$<1 \times 10^{-3}$	Not Yet	7.0H x 2.0V	2 to 28H
120 - ~400	400	$\sim 1 \times 10^{-3}$	Measured	7.0H x 2.0V	2 to 28H

Optical Configuration

a) **Mirror**

1:1 focusing aluminum gold coated toroidal mirror; focuses beam onto fixed entrance slit of monochromator; size is 120 mm x 240 mm x 50 mm; sagittal radius is 152 mm and meridional radius is 42,230 mm; angle of incidence is 87°; located 2.47 meters from the source.

b) **Monochromator**

Toroidal grating monochromator; gratings interchangeable in UHV; laminar etched quartz gold coated gratings; grating focuses beam onto exit slit in inside order; grating angle of incidence at zero order is 3°, sagittal radius is 73.9 mm, meridional radius is 66,160 mm; exit slit distance adjustable between 11,370 - 12,370 mm from source; monochromator located 6.77 meters from the source.

Experimental Apparatus

Ultra-high vacuum sample chamber having manipulator with xyz movement and z-axis rotation; liquid He cryostat (down to 15° K); 100 mm radius hemispherical analyzer; LEED/Auger facilities.

Computer System Hardware and Software

IBM XT computer.

April 22, 1987

Beam Line:	U7B
Ring:	VUV
Operational Status:	Operational

Participating Institutions: BNL - Physics Department, SUNY at Stony Brook

Local Contact: Francis Loeb (516)282-5507, 2092; BNL

Spokesperson: Myron Strongin (516)282-3763; BNL

Research Program: ARUPS, SEXAFS

Energy Range (eV)	Flux at Exit Slit (phot./sec./A/ 0.2% bw)	Total Acceptance Angle (mradians)	Spot Size - typical - focussed (mm)	Angle of Incidence at Zero Order (degrees)	Mirror
350 - 1200	5×10^{10}	4.0H x 1.0V	3.0H x 1.0V	88°	P1
80 - 400	5×10^{10}	4.0H x 1.0V	3.0H x 1.0V	86°	P2
30 - 150	5×10^{10}	4.0H x 1.0V	3.0H x 1.0V	80°	P3
15 - 80	5×10^{10}	4.0H x 1.0V	3.0H x 1.0V	67°	P4

Optical Configuration

Monochromator

Three-element plane grating grazing monochromator; focal point at exit slit at 11 meters from source; $\Delta\lambda/\lambda = 1 \times 10^{-2}$; no refocusing after exit slit; demagnification of source is 0.1; divergence at exit slit is 40 mradH x 10 mradV; located 10 meters from the source.

a) **Mirror No. 1**
Nickel coated parabolic collimating aluminum mirror; focal length of 10 meters; angle of incidence fixed at 88°.

b) **Grating**
SiO_2 gold plated grating; rectangular ruled; 600 grooves/mm; depth of groove is 200 Å.

c) **Mirror No. 2 (P1 - P4)**
Nickel coated parabolic focusing aluminum mirror; focal length of ~1 meter; four mirrors are available dependent on angle of incidence.

Experimental Apparatus

Ultra-high vacuum sample chamber - manipulator with xyz movement and z-axis rotation; VG APES 400 hemispherical analyzer ($\Delta E/E \sim 0.01$) mounted on two-axis goniometer; LEED/Auger facilities; no differential pumping.

Computer System Hardware and Software

Beam line apparatus controlled by DEC 11/23 over UNIBUS driven CAMAC crate, accepts up to ~200 kHz count rate (data analysis, storage, and general control by IBM with 360K/1.2 MB floppy drive, 10 MB hard disk drive, 512K RAM available in early 1987), real time data storage on hard disk, data output on floppy diskette.

April 22, 1987

Beam Line:	U8A
Ring:	VUV
Operational Status:	Operational

Participating Institutions: IBM - T.J. Watson Research Center

Local Contact: Amina Taleb-Ibrahimi (516)282-5508, 5303: BNL

Spokesperson: Read McFeely (914)945-2068; IBM

Research Program: ARUPS, NEXAFS

Energy Range (eV)	Grating Type (grooves/mm)	Resolution (eV)	Flux (photons/sec)	Spot Size -focused (mm)	Total Horizontal Angular Acceptance (mradians)
7 - 30	450	$\leq$0.5	1 x 10^{11} in a 1 eV band pass (50 mA, 750 MeV)	1.0H x 1.0V	~25
30 - 130	1800	$\leq$0.5		1.0H x 1.0V	~25

Optical Configuration

a) **Mirror No. 1**
Quartz gold coated toroidal mirror for collecting light from source; located 2.1 meters from the source.

b) **Mirror No. 2**
Quartz gold coated planar mirror for deflecting light to monochromator; angle of incidence is 6°; located 2.5 meters from source.

c) **Mirror No. 3**
Quartz gold coated toroidal mirror for focusing source onto monochromator entrance slit; located 7.6 meters from source.

d) **Monochromator**
Three meter focal length toroidal blazed grating monochromator; quartz gold coated gratings; in-vacuum (UHV) interchangeability of two gratings using Geneva mechanism; manually adjustable entrance and exit slits; located 9.9 meters from source.

e) **Mirror No. 4**
Quartz gold coated toroidal mirror for focusing onto sample at 13.5 meters from source; current collected from mirror surface used for photon reference channel; located 12.9 meters from source.

Experimental Apparatus

Introduction, sample prep and spectroscopy chambers are separated by gate valves and independently pumped; gas dosing capabilities in introduction and prep chambers; magazine for four samples in prep chamber; spectroscopy chamber pressure maintained at $<5 \times 10^{-10}$ Torr at all times; sample heating available; Auger spectrometer; LEED; hemispherical electron energy analyzer mounted on a two-axis cradle with $\sim 2\pi$ steradians movement capability for ARPES photoemission spectroscopy.

Computer System Hardware and Software

IBM Series 1 computer programmed to take EDC, CFS and zero order scans; EDX operating system; data stored on Series 1 IBM 4963 64 MB disk transferrable to IBM 4965 2.4 MB diskettes; Tektronix 4015-1 graphics terminal displays data as they are collected; Tektronix 4631 hardcopy unit available; IBM 4973 printer; IBM 4978 display terminal; IBM 4955F 512K processor.

April 17, 1987

Beam Line:	U8B
Ring:	VUV
Operational Status:	Operational

Participating Institutions: IBM - T.J. Watson Research Center

Local Contact: Amina Taleb-Ibrahimi (516)282-5508, 5303: BNL

Spokesperson: Read McFeely (914)945-2068; IBM

Research Program: ARUPS, NEXAFS

Energy Range (eV)	Grating Type (grooves/mm)	Resolution (eV)	Flux (photons/sec)	Spot Size -focused (mm)	Total Horizontal Angular Acceptance (mradians)
70 - 180[1]	288	generally		1.0H x 1.0V	~25
25 - 70[1]	822	0.1 to 0.5		1.0H x 1.0V	~25
5 - 25[1]	2400		1×10^{11} in a 1 eV band pass (50 mA, 750 MeV)	1.0H x 1.0V	~25
300 - 1000[2]	800	0.17 for C(1s)		1.0H x 1.0V	~25
250 - 700[2]	1200	absorption at		1.0H x 1.0V	~25
180 - 400[2]	1800	C_{edge} (287 eV)		1.0H x 1.0V	~25

[1]six meter TGM; [2]ten meter TGM

Optical Configuration

a1) **Mirror No. 1**
Quartz gold coated toroidal mirror, focuses light on entrance slit of 10 meter TGM; 2° angle of incidence; located 2.1 meters from source.

a2) **Mirror No. 2**
Quartz gold coated toroidal mirror, focuses light on entrance slit of 6 meter TGM; 2° angle of incidence; located 2.1 meters from source.

b) **Monochromators**
Single element toroidal grating monochromators (TGM); quartz gold coated, holographically ruled, ion-etched gratings; three gratings/TGM interchangeable in UHV on revolver type mount; entrance and exit slits moveable in three coordinates in UHV; for 6 meter TGM the angle of incidence is 10° and the toroidal grating radii are 470.5 mm (sagittal) and 19,246 mm (meridional); for the 10 meter TGM the angle of incidence is 4° and the toroidal grating radii are 288 mm (sagittal) and 71,116 mm (meridional); located 7.1 meters from source.

c) **Mirror No. 3**
Quartz gold coated planar mirror deflects light from 6 meter TGM onto horizontal path; 8° angle of incidence; located 8.4 meters from source.

d) **Mirror No. 4**
Quartz gold coated toroidal mirror for focusing and steering light from 6 meter TGM onto 6 meter exit slit; 2° angle of incidence; located 12.5 meters from source.

e) **Mirror No. 5**
Quartz gold coated toroidal mirror demagnifies beam by 0.25 from the common exit slit onto the sample 0.6 meters downstream; located 16 meters from source.

Experimental Apparatus

Introduction, sample prep and spectroscopy chambers are separated by UHV valves and independently pumped; magazines for six samples in prep chamber; gas dosing capabilities in introduction and sample prep chambers; evaporation, ion bombardment, LEED, sample

heating and cleavage capabilities in prep chamber; spectroscopy chamber pressure maintained at $<1 \times 10^{-10}$ Torr ; spectroscopy chamber contains high resolution ellipsoidal mirror display analyzer system with $\sim$1.8 steradian angular acceptance for electron energy analysis.

Computer System Hardware and Software

IBM Series 1 computer programmed to take EDC, CFS and zero order scans; EDX operating system; data stored on Series 1 IBM 4963 64 MB disk transferrable to IBM 4965 2.4 MB diskettes; Tektronix 4015-1 graphics terminal displays data as they are collected; Tektronix 4631 hardcopy unit available; IBM 4973 printer; IBM 4978 display terminal; IBM 4955F 512K processor.

April 20, 1987

Beam Line:	U8C
Ring:	VUV
Operational Status:	Operational

Participating Institutions: IBM - T.J. Watson Research Center

Local Contact: Eberhard Spiller (914)945-2447; IBM

Spokesperson: Eberhard Spiller

Research Program: Evaluation of a zone plate monochromator, reflectivity measurements of thin films and multilayers

Expected Values				
Wavelength Range (Å)	Zone Plate - diameter smallest period	Resolution ($\lambda/\Delta\lambda$)	Slit Size (μm)	Total Angular Acceptance (mradians)
20 - 35	5 mm; 0.4 μm	500 - 1000 expected	100H x 30V	0.5H x 0.5V
30 - 55	7 mm; 0.6μm	140 @ 45 Å with 0.5 mm source measured; 700 with 0.1 mm spot expected	100H x 30V	0.7H x 0.7V

Flux has not been measured but can be estimated from the diffraction efficiency of the zone plates (3 - 10%) and angular acceptance (0.5 x 0.5 mrad or 0.7 x 0.7 mrad). Presently only two zone plates are installed; longer wavelengths can be obtained by the use of coarser zone plates.

Optical Configuration

Off-Axis Zone Plates

These image the synchrotron source onto the exit slit; wavelengths are tuned by a linear translation of the zone plates; distance between zone plates and exit slit is presently between 1.70 and 3.30 meters; zone plates are ~10 meters from source point. The resolution is limited by the source size and 0.1 mm is required for $\lambda/\Delta\lambda \sim 1000$; the image of the source is 9 mm below the incident beam; the exit slit is fixed during wavelength tuning, but the direction of the exit beam changes ~ 2 mrad within the tuning range; the exit beam diverges from the exit slit with the angular acceptance (0.5 or 0.7 mrad).

Experimental Apparatus

Reflectometer sample chamber with capability to rotate mirrors and detector; parts to mount filters and measure transmission; standard mirror size is 25 mm x 25 mm and up to 50 mm x 50 mm is possible.

Computer System Hardware and Software

IBM PC computer for rotation of mirror and detector and for data analysis.

April 21, 1987

Beam Line:	U8D
Ring:	VUV
Operational Status:	Operational Fall 87

Participating Institutions: IBM - T.J. Watson Research Center

Local Contact: Eberhard Spiller (914)945-2447; IBM

Spokesperson: Eberhard Spiller

Research Program: Scanning soft x-ray microscopy

Expected Values			
Wavelength at Focal Point Behind Microscope (Å)	Flux at Focal Point Behind Microscope (phot./sec./0.1A/1%bw)	Resolution by Microscope (Å)	Total Angular Acceptance (mrad)
Current microscope mirror coatings produce 67 Å with 1% bw. Wavelengths as short as 45 Å are possible.	5×10^6	500H x 500V	1.0H x 0.5V at first mirror

Optical Configuration

a) **Mirror No. 1**
Grazing incidence ellipsoidal mirror, deflects beam by 6° and images source onto pinhole collimator; grazing angle (Θ) is 3°; located 5.7 meters from source.

b) **Pinhole**
Collimates beam producing a source for the Schwarzschild objective; pinhole size adjustable (2 - 20 μm); located 6 meters from source.

c) **Schwarzschild Objective**
Two normal incidence mirror system; demagnifies pinhole image by 64 at sample; located 9 meters from source.

Experimental Apparatus

Chamber consisting of two parts, one for mirrors and the other for specimen and scan mechanism; both chambers may be evacuated to rough vacuum or separated by polyimide window for observation of specimen in air or helium; flow proportional counter with P10 gas for detecting transmitted photons.

Computer System Hardware and Software

IBM PC running piezoelectric x-y raster scan stage in specimen chamber.

April 21, 1987

Beam Line:	U9A
Ring:	VUV
Operational Status:	Operational

Participating Institutions: NSLS, BNL - Chemistry Department

Local Contact: Jack Preses (516)282-5509, 4371; BNL

Spokesperson: Ralph Weston (516)282-4373; BNL

Research Program: Fluorescence lifetimes, photoconductivity, photoionization

Spectral Range Å (eV)	Grating Type (grooves/mm)	Resolution (Å/mm)	Flux @ 1216 Å (phot./sec./A/ mm input slit)	Spot Size at Cell focused (mm)	Total Angular Acceptance (mrads)
1050 - 2950 (12 - 4)	1200 (blazed for 1500 Å)	16.7	10^{10}	5.0H x 2.0V	32H x 10V
3000 - 6000 (4 - 2)	600 (blazed for 3500 Å)	33.4		5.0H x 2.0V	32H x 10V
6000 - 12,000 (2 - 1)	300 (blazed for 7000 Å)	66.8		5.0H x 2.0V	32H x 10V

Optical Configuration

a) **Mirror No. 1**
Copper planar mirror coated with electroless nickel, coated with gold ; non-adjustable; at approximately normal incidence angle; located 1200 mm from the source.

b) **Mirror No. 2**
Pyrex spherical mirror coated with aluminum, coated with magnesium fluoride; at normal incidence angle; located 2500 mm from the source. The above two mirrors are at ultrahigh vacuum and are separated from the downstream beam line (kept at 10^{-7} Torr) by a lithium fluoride window which effectively limits the wavelength to 1050 Å and longer.

c) **Mirror No. 3**
Pyrex cylindrical mirror with aluminum, coated with magnesium fluoride, focusing light onto input slit of monochromator; fully manually adjustable; 4000 mm from the source.

d) **Monochromator**
One-half meter Seya-Namioka monochromator; single concave fused silica/epoxy grating with manually adjustable input and output slit; gratings are coated with aluminum and overcoated with magnesium fluoride; located 4500 mm from the source.

e) **Mirror No. 4**
Eyeglass toroidal softglass mirror coated with aluminum, coated with magnesium fluoride for focusing astigmatic source onto focal point 1 meter downstream in sample chamber; empirical alignment; located 5000 mm from the source.

Experimental Apparatus

Sample chamber (8 inch conflat cross) holds sample cells - front and side window fluorescence sample cells with lithium fluoride windows, photoconductivity cells, windowless oven, high vacuum or air operations possible; RCA C31034A-A02 and EMI 9813QA and Hamamatsu 855 photomultipliers.

Computer System Hardware and Software

LeCroy 3500M MCA with CP/M operating system; PDP 11/73 computer with RSX-llM (4.2) operating system and dual RL02 plus RX02 disks; VAX 11/730 computer with VAX/VMS (4.6) operating system, dual RX02 disk, R80 disk, dual TU58 tape, RX50, TK50; PDP and VAX use DECnet/Ethernet network; Tektronix 4006-1 graphics terminal; HP7470A plotter; menu-driven data acquisition and analysis software.

April 24, 1987

Beam Line:	U9B
Ring:	VUV
Operational Status:	Operational

Participating Institutions: NSLS, BNL - Biology Department

Local Contact: John Sutherland (516)282-5509, 3406; BNL

Spokesperson: John Sutherland

Research Program: Circular dichroism (CD), magnetic circular dichroism (MCD), fluorescence lifetimes (FL)

Energy range nm (eV)	Spectrometer Type	Application	Resolution (nm/mm)	Image Size at Sample (mm diameter)	Total Angular Acceptance (mradians)
140 - 600 (8.9 - 2.1)	Vacuum	CD, MCD FL	1.67	2	37H x 10V
220 - 600 (5.6 - 2.1)	Non-vacuum	FL		2	37H x 10V

Optical Configuration

a) **Mirror No. 1**
Copper planar mirror coated with electroless nickel, coated with gold; not adjustable; at normal incidence angle; deflects beam 90° down from horizontal; located 2.5 meters from the source.

b) **Mirror No. 2**
Pyrex off-axis ellipsoid mirror coated with aluminum, coated with magnesium fluoride; reflects beam into horizontal perpendicular to the original beam thereby erecting it; predominant polarization is vertical; at normal incidence angle; steerable via remote controls; focal point at entrance slits of monochromators; located 2.7 meters from the source.

c) **Mirror No. 3**
Rotatable planar quartz mirror coated with aluminum, coated with magnesium fluoride; deflects beam by 90° toward fluorometer monochromator (d1) or allows beam to pass straight through to vacuum spectrometer monochromator (d2); 2:1 demagnification; located 3.5 meters from the source.

d1) **Fluorometer Monochromator**
Czerney-Turner prism grating double monochromator dedicated to fluorometer; operates at atmosphere and separated from UHV by quartz window; 30° quartz prism followed by 600 grooves/mm echellet quartz grating coated by aluminum, coated by magnesium fluoride; 0 - 3 mm ganged entrance and exit slits; located 4.75 meters from the source.

d2) **Spectrometer Monochromator**
One-half meter Czerney-Turner single grating vacuum monochromator dedicated to vacuum spectrometer; operates at high vacuum (10^{-7} Torr) and separated from UHV by calcium fluoride window; 1200 grooves/mm holographic quartz grating coated by aluminum, coated by magnesium fluoride; 0 - 3 mm independent entrance and exit slits; located 4.75 meters from the source.

Experimental Apparatus

For Fluorometer
Fluorescence lifetime spectrometer with holders on excitation and emission axes for multiple optical elements (polarizers and depolarizers) controlled by stepping motors; sample heater at -10° to 90°C; cryostat from -190° to 20°C; one meter Czerney-Turner 4 inch grating

emission monochromator, grating has 1200 grooves/mm, 0 - 3 mm continuous adjustment (high resolution) slits and 0 - 20 mm slits in 1, 2, 5, 10, 20 mm adjustments (high throughput).

For Vacuum System

For circular dichroism a calcium fluoride photoelastic modulator, vacuum down to 0.001 Torr, sample thermal control from -20 ° to 90 ° C, sample is in exact center of double cross; for magnetic circular dichroism, a 2.3 Tesla electromagnet, sample is in exact center of a double cross; evacuable emission monochromator.

Computer System Hardware and Software

Both spectrometers are operated by a Tektronix 4052 graphics computer with direct serial connection to a MicroVAX II computer with VAX/VMS (v.4.5) operating system, dual 5 1/4" floppy disk, RD53 Winchester disk, TK50 and optical WORM disk for archival storage; LeCroy 3500M MCA with firmware operating system dedicated to fluorometer.

April 30, 1987

Beam Line:	U10A
Ring:	VUV
Operational Status:	Operational

Participarting Institutions: U. of Tennessee, Oak Ridge National Laboratory, National Bureau of Standards

Local Contact: K.L. Tsang (516)282-5510; BNL

Spokesperson: Thomas Calcott (615)974-7848; U. of Tennessee

Research Program: X-ray fluorescence, soft x-ray emission (20 - 1000 eV), soft x-ray absorption, electron spectroscopy

Energy Range (eV)	Grating Type (grooves/mm)	Resolution ($\Delta\lambda$)	Flux (phot./sec.)	Beam Size - focused (mm)	Total Angular Acceptance (mradians)
White Beam		White Beam	White Beam	4H x 0.2V (1:1 of SLS beam)	10H x 2V
20 - 1000	1000	1 Å	$\sim 10^{12}$	4H x 0.2V (1:1 of SLS beam)	10H x 2V

Optical Configuration

a) **Mirror**
Fused silica toroidal focusing mirror imaging the beam onto sample located 6390 mm from source, mirror is gold coated, sagittal radius is 112 mm, meridional radius is 92 m; double bellows design allows bending and positioning of mirror box; operates at UHV; high energy cutoff is ~1000 eV; mirror is located 3200 mm from the source.

b) **Monochromator**
Normal incidence transmission grating monochromator; scanning with plane mirrors; reflection filters to eliminate high order interferences; located 4000 mm from the source.

Experimental Apparatus

UHV sample chamber using a Huntington xyz-rotation manipulator mount, spherical analyzer, several access ports available; soft x-ray spectrometer consists of input slit located 2 - 4 mm from sample, grating chamber with four original toroidal gratings ruled in gold or SiO_2 substrates and a two-dimensional detector; detector system has a microchannel plate coupled by fiber optics to a 320 x 512 pixel cooled CCD Si-diode array; system provides measuring efficiencies 10^3 to 10^4 times higher than conventional Rowland circle spectrometers.

Computer System Hardware and Software

CAMAC data acquisition using DEC LSI-11 processor and RT-11 operating system; hard disk; graphics terminal and graphics plotter.

May 8, 1987

Beam Line:	U10B
Ring:	VUV
Operational Status:	Operational

Participating Institutions: NSLS, Superconducting Super Collider

Local Contact: Joseph Schuchman (516)282-4630; BNL

Spokesperson: Joseph Schuchman

Research Program: Stimulated desorption

Energy Range (eV)	Resolution (ΔE/E)	Flux (phot./sec./mA)	Beam Size - unfocused (mm)	Total Horizontal Angular Acceptance (mradians)
White Beam	White Beam	9.61×10^{14}	51H x 51V - typical	15 (max.)

Optical Configuration

Beam line has neither mirrors nor monochromator.

a) **Collimator Box**
Adjustable horizontal and vertical slits; moveable horizontal and vertical wires and readouts for measuring position and intensity; located 4.5 meters from the source.

b) **Double Bellows Chamber**
Rotatable chamber used to change angle of incidence to sample; located 4.9 meters from the source.

Experimental Apparatus

Calibrated RGA; other equipment, including sample chamber (located 5.1 meters from the source), should be supplied by the user.

Computer System Hardware and Software

None at present.

April 27, 1987

Beam Line:	U11
Ring:	VUV
Operational Status:	Operational

Participating Institutions: NSLS, BNL - Chemistry Dept., U. of New Mexico, Argonne National Laboratory, Yale U., Boston U.

Local Contact: Michael White (516)282-5511, 4345; BNL
J. Robb Grover (516)282-5511, 4348; BNL

Spokesperson: Michael White, J. Robb Grover

Research Program: Gas phase photoionization

Spectral Range Å (eV)	Grating Type (grooves/mm)	Resolution @ 200 μm Slit (Δλ)	Flux (phot./sec.)	Spot Size at Interaction Pt. (mm diameter)	Total Angular Acceptance (mradians)
450 - 4000 (28 - 3)	1200	1.5	1×10^{13} (1000 Å, 100 mA)	1.0	55H x 10V
350 - 1400 (35 - 9)	3600	0.5	1×10^{11} (600 Å, 100mA)	1.0	55H x 10V
450 - 1500 (28 - 8)	3600	0.5	1×10^{11} (1000 Å, 100 mA)	1.0	55H x 10V

Optical Configuration

Monochromator

Modified Wadsworth normal incidence monochromator located 2.7 meters from the source.

a) **Mirror**

Spherical concave quartz blank osmium coated mirror; mirror is water cooled and fixed position; 200 mm by 50 mm with 2.8 meter radius; dumps hard x-ray radiation and provides parallel rays to grating; 6° angle of incidence; high energy cutoff is 41 eV (300 Å).

b) **Gratings**

Spherical concave 4 meter radius focusing gratings, vertical focal point at exit slit 2 meters beyond monochromator, horizontal focal point and interaction point 27 mm beyond exit slit; all have same dimensions as mirror; 1200 grooves/mm grating is a quartz blank osmium coated ion etched laminar grating, highest efficiency below 11 eV (1100 Å); first 3600 groove/mm grating is a quartz blank osmium coated Bausch and Lomb replica blazed at 304 Å, maximum efficiency at 24.8 eV (500 Å); second 3600 groove/mm grating is a quartz blank osmium coated holographic grating, highest efficiency at longer wavelengths (>800 Å).

Experimental Apparatus

Supersonic molecular beam photoionization mass spectrometer, triply differentially pumped molecular beam, 1 - 2 atmosphere expansion of permanent gasses, expansions of low vapor liquids, heating up to 150° C; quadrupole mass spectrometer for mass analysis with range up to 200 amu.

Computer System Hardware and Software

PDP 11/23 computer; RT-11 (v.4) operating system, 256K memory; two RX02 and two RL02 disk drives; LA120 hardcopy terminal; VT100 graphics terminal; LA50 hardcopy; HP7470A plotter; CAMAC interface controlled experimental station and monochromator drive; DECnet and Ethernet to VAX 11/730 at U9A beam line; Gandalf link to CHEM/AMD computer systems; RSX conversion; data acquisition and analysis programs for running mass spectrometers are available.

April 24, 1987

Beam Line:	U12A
Ring:	VUV
Operational Status:	Construction Operational early 88

Participating Institutions: U. of Pennsylvania - Department of Physics, Oak Ridge National Laboratory - Solid State Division

Local Contact: Xiaohe Pan (516)282-5512, 5210; BNL

Spokesperson: E.W. Plummer (215)898-8157; U. of Pennsylvania
D. Zehner (615)574-6291; Oak Ridge National Laboratory

Research Program: High resolution core level spectroscopy

Expected Values					
Spectral Range Å (eV)	Grating Type (grooves/mm)	Resolution (Å)	Flux (phot./sec.)	Spot Diameter at Sample (mm)	Total Angular Acceptance (mradians)
25 - 70 (496 - 177)	600				20H x 2V
10 - 30 (1240 - 413)	1200				20H x 2V

Optical Configuration

Monochromator

Toroidal mirror, 3° toroidal grating monochromator, located 7.0 meters from the source.

a) **Front Mirror**
Gold coated aluminum toroidal mirror, 100 mm x 50 mm, sagittal radius is 152 mm, meridional radius is 42.3 m; vertical focus is at the entrance slit 2.5 meters upstream of the grating; horizontal focus is 1 meter upstream of the grating; inclined at 3° to the horizontal plane.

b) **Grating**
Gold coated Spectrosil "B" toroidal grating, 100 mm x 50 mm, ion etched sagittal radius is 220 mm, meridional radius is 88 m; two gratings are available and exchangeable in situ in UHV; exit slit is moveable along a 0.75 m path parallel to the beam.

Experimental Apparatus (Planned)

Sample chamber equipped with a hemishperical electrostatic analyzer for core level spectroscopy of molecules and adsorbates.

Computer System Hardware and Software

AT&T PC6300 computer.

May 3, 1987

Beam Line:	U12B
Ring:	VUV
Operational Status:	Operational

Participating Institutions: U. of Pennsylvania - Department of Physics, Oak Ridge National Laboratory - Solid State Division

Local Contact: Xiaohe Pan (516)282-5512, 5210; BNL

Spokesperson: E.W. Plummer (215)898-8157; U. of Pennsylvania
D. Zehner (615)574-6291; Oak Ridge National Laboratory

Research Program: Angle-resolved photoemission

Expected Values					
Spectral Range Å (eV)	Grating Type (grooves/mm)	Resolution (Å)	Flux - 0.1 eV band pass (phot./sec.)	Spot Diameter at Sample - focused (mm)	Total Angular Acceptance (mradians)
320 - 1280 (39 - 10)	450	0.74 @ 460 Å	5×10^{12} @ 30 eV (100 mA, 750 MeV)	2	50H x 6V
80 - 320 (155 - 39)	1800	0.32 @ 136 Å	1×10^{12} @ 100 eV (100 mA, 750 MeV)	2	50H x 6V

Optical Configuration

Monochromator

15° toroidal grating monochromator, located 5.8 meters from the source.

a) **Front Mirror**
Gold coated aluminum ellipsoidal mirror, 125 mm x 110 mm; 0.89 magnification ; focuses at entrance slit; inclined at 7.5° to the horizontal plane.

b) **Post Mirror**
Glass ellipsoidal mirror; 0.5 magnification; focuses at the sample; inclined at 7.5° to the horizontal plane.

c) **Grating**
Toroidal gratings, holographically ruled; two gratings available and exchangeable in situ in UHV; exit slit located 1.92 meters downstream from gratings, slit position corresponds to the horizontal and vertical focus at 130 Å; maximum efficiencies at 30 eV and 90 eV for the low and high energy grating respectively.

Experimental Apparatus

Sample chamber equipped with a rotatable hemispherical electrostatic analyzer and a cryogenic manipulator capable of sample rotation around the vertical as well as the beam axes; sample preparation and characterization include an ion sputtering gun, back view LEED facility, cylindrical mirror analyzer for Auger electron spectroscopy, angle integrated photoemission setup.

Computer System Hardware and Software

AT&T PC6300 computer, CAMAC interface controlling experiment.

May 3, 1987

Beam Line:	U12C
Ring:	VUV
Operational Status:	Construction Operational early 88

Participating Institutions: U. of Pennsylvania - Department of Physics, Oak Ridge National Laboratory - Solid State Division

Local Contact: David R. Heskett (215)898-7987; U. of Pennsylvania

Spokesperson: E.W. Plummer (215)898-8157; U. of Pennsylvania

Research Program: Infrared vibrational spectroscopy

Expected Values					
Wavelength Range (cm^{-1})	Grating Type (grooves/mm)	Blaze (cm^{-1})	Resolution (cm^{-1})	Flux (phot./sec./ 0.1% bw)	Total Angular Acceptance (mradians)
1680 - 5884	300	3390	~1 - 10	$\sim 10^{14}$	40H x 10V
840 - 2942	150	1700	"	@ 4000 cm^{-1}	"
407 - 1471	75	847	"		"
225 - 785	40	452	"		"
112 - 392	20	220	"	$\sim 10^{13}$	"
56 - 196	10	113	"	@ 300 cm^{1-}	"

Optical Configuration

a) **Mirror No. 1**
Elliptical electroless nickel plated aluminum mirror; adjustable; refocuses light from source onto entrance slit; focal lengths - located 224 cm from source and 195 cm from monochromator entrance slit.

b) **Mirror No. 2 and 3**
Plane gold coated glass mirrors; deflect light down the beam line to the entrance slit.

c) **Filter Box**
Long wavepass filters plus variable filter wheel covering 2 - 14 μm range.

d) **Monochromator**
Czerney-Turner monochromator with two plane and two spherical (320 cm radii of curvature) gold coated glass mirrors; plane ruled Bausch and Lomb gratings interchangeable in UHV.

e) **Mirror No. 8**
Plane gold coated glass mirror; deflects beam onto Mirror No. 9.

f) **Mirror No. 9**
Elliptical gold coated fused silica mirror; refocuses light from exit slit onto sample; focal lengths - located 140 cm downstream of monochromator exit slit and 70 cm upstream of sample.

g) **Sample Chamber**
30.5 cm diameter stainless steel UHV chamber.

h) **Mirror No. 10**
Plane gold coated glass mirror; deflects beam from sample onto Mirror No. 11.

i) **Mirror No. 11**
Elliptical gold coated fused silica mirror; refocuses light from sample onto detector; focal lengths - located 70 cm downstream of sample and 70 cm upstream of detector; beam line is UHV past Mirror No. 11 and is separated from the rest of the beam line by a CaF_2 window.

Spot size will be ~2 mm x 10 mm.

Experimental Apparatus

Ge:Au infrared detector mounted on a liquid-N_2 cooled dewar, equipped with a Si window, spectral range is 2 - 10 μm; in the future a Ge:Cu detector will be added having a 2 - 30 μm spectral range.

Computer System Hardware and Software

Data acquisition system is not finalized at this time.

May 3, 1987

Beam Line:	U13-TOK
Ring:	VUV
Operational Status:	Commissioning

Insertion Device Team: NSLS, AT&T Bell Labs

Local Contact: Anne-Marie Fauchet (516)282-5028; BNL

Spokesperson: Anne-Marie Fauchet

Research Program: Development of coherent ultraviolet radiation source using the Transverse Optical Klystron (TOK) wiggler

Expected Values (spontaneous source)			
Energy Range (eV)	Source	Flux (phot./sec./mrad/ A/0.1% bw)	Total Horizontal Angular Acceptance (mradians)
10 - 1000	TOK Wiggler - K_{RMS} ~5.5 at minimum gap - 22.5 periods - 10 cm period	5×10^{14} @ 54 Å (750 MeV)	10.5*

* 10.5 mradians up to U13U mirror box; 4.5 mradians on the rest of U13-TOK beam line.

Coherent Source (proposed)

a) **Mode #1**
Coherent harmonics of high power lasers (Nd:YAG, ArF, dye laser) down to ~500 Å; ring operation at low energy (400 MeV) necessary with present wiggler and laser parameters.

b) **Mode #2**
Visible-near UV free-electron laser; ring operation at low energy.

Experimental Apparatus

a) Spontaneous radiation from TOK wiggler will only be available for experimental use from the U13U line in the near term.

b) U13-TOK beam line is dedicated to coherent UV source development at the present time; optical configuration and experimental apparatus are available for characterization of the source but are not yet planned for the experimental use of the coherent source.

Computer System Hardware and Software

Not yet defined.

May 2, 1987

Beam Line:	U13U
Ring:	VUV
Operational Status:	Operational Spring 88

Insertion Device Team: NSLS, Montana State U., U. of Wisconsin at Milwaukee, Drexel U., Brandeis U., AT & T Bell Labs

Local Contact: Steven Hulbert (516)282-7570; BNL

Spokesperson: Steven Hulbert
Wayne Ford (406)994-6156; Montana State U.

Research Program: High resolution VUV/soft X-ray electron and ion spectroscopies

Expected Values						
Energy Range (eV)	Grating Type (grooves/mm)	Included Angle (deg.)	Source/Mode	Resolution ($\Delta E/E$)	Flux at 750 MeV Source (phot./sec./ A/0.1% bw)	Total Horizontal Angular Acceptance (mradians)
407 - 1215	1200	174°	TOK*/Wiggler	$\geq 1 \times 10^{-3}$	2×10^{15}	6.2**
204 - 607	600	174°	TOK/Wiggler	$\geq 1 \times 10^{-3}$	3×10^{15}	6.2**
102 - 304	300	174°	TOK/Wig.-Und.	$\geq 1 \times 10^{-3}$	4×10^{15}	6.2
10 - 150	?	160°	TOK/Undulator	$\geq 1 \times 10^{-3}$	$1\text{-}2 \times 10^{15}$	all

*TOK=Transverse Optical Klystron **1.2 K/γ

Optical Configuration

a) **Mirror No. 1**
Gold coated spherical horizontal collecting and focusing mirror, redirects beam from U13-TOK line to the U13U spectroscopy line and focuses beam onto sample; mirror is 105 cm long and has a 3° grazing angle of incidence; fixed position; located 9 meters from center of TOK.

b) **Mirror No. 2**
Gold coated spherical vertical collecting and focusing mirror, focuses beam onto entrance slit of monochromator; mirror is 50 cm long and has a 2° grazing angle of incidence; fixed position; located 10 meters from center of TOK.

c) **Monochromator**
Constant included angle mount for grating, similar to a toroidal grating monochromator; fixed entrance and moveable exit slit geometry; grating movement rotational only; gratings are spherical, blazed, gold coated silica, up to 5 can be interchanged in situ in UHV; locations from center of TOK - entrance slit=15 meters, gratings=17 meters, exit slit=21.0-21.8 meters.

Experimental Apparatus

Separate sample chambers will be built by the various members of the PRT; light from the low energy grating may either be directed to the main sample chamber by two planar mirrors or may be directed to a separate sample chamber; this allows sequential use of two chambers.

Computer System Hardware and Software

No information currently available.

April 14, 1987

Beam Line:	U14A
Ring:	VUV
Operational Status:	Operational

Participating Institutions: National Synchrotron Light Source

Local Contact: Carol Hirschmugl (516)282-5514, 7253; BNL

Spokesperson: Richard Garrett (516)282-4245; BNL

Research Program: Solid state photoemissions studies

Energy Range (eV)	Flux at Exit Slit (phot./sec./amp/ 0.2% bw)	Total Acceptance Angle (mradians)	Spotsize -typical -focused (mm)	Angle of Incidence at Zero Order (degrees)	Mirror
350 - 1200	5×10^{10}	4.0H x 1.0V	3.0H x 1.0V	88 °	P1
80 - 400	5×10^{10}	4.0H x 1.0V	3.0H x 1.0V	86 °	P2
30 - 150	5×10^{10}	4.0H x 1.0V	3.0H x 1.0V	80 °	P3
15 - 80	5×10^{10}	4.0H x 1.0V	3.0H x 1.0V	67 °	P4

Optical Configuration

Monochromator

Three-element plane grating grazing monochromator; focal point at exit slit at 11 meters from source; $\Delta\lambda/\lambda = 3 \times 10^{-3}$; no refocusing after exit slit; demagnification of source is 0.1; divergence at exit slit is 40 mradians H x 10 mradians V; located 10 meters from source.

a) **Mirror No. 1**
Nickel coated parabolic collimating aluminum mirror; focal length of 10 meters; angle of incidence at 88 ° .

b) **Grating**
SiO_2 gold plated grating; rectangular ruled; 600 rules/mm; depth of rule is 200 Å.

c) **Mirror No. 2 (P1 - P4)**
Nickel coated parabolic focusing aluminum mirror; focal length of $\sim$ 1 meter; four mirrors are available dependent on angle of incidence.

Experimental Apparatus

Ultra-high vacuum sample chamber - manipulator with xyz movement and z-axis rotation, double pass cylindrical mirror analyzer with 0.02 ($\Delta E/E$) resolving power, hemispherical VG angularly resolved analyzer with 2-axis goniometer, LEED/Auger facilities, I_o flux monitors (grid, diode), no differential pumping; ultra-high vacuum prep chamber - sample storage for up to 20 samples, in-vacuum transfer to sample chamber, air-to-vacuum sample transfer system.

Computer System Hardware and Software

Beam line apparatus controlled by Tektronix 4052 over GPIB, accepts up to $\sim$ 200 kHz count rate (data analysis, storage and general control by IBM AT with 360K/1.2 MB floppy drive, 30 MB hard disk drive, 1024K RAM, Venix operating system, available in mid-1987).

April 15, 1987

Beam Line:	U15
Ring:	VUV
Operational Status:	Operational

Participating Institutions: NSLS, SUNY at Stony Brook, IBM, Lawrence Berkeley Laboratory

Local Contact: Waiman Ng (516)282-5515, 4723; BNL

Spokesperson: Janos Kirz (516)632-8106; SUNY at Stony Brook

Research Program: Soft x-ray spectroscopy (solids and gasses), contact microscopy

Wavelength Range (Å)	Grating Type (grooves/mm)	Resolution ($\Delta E/E$)	Flux (phot./sec./ 1.0%bw)	Spotsize Radius Focused with Fresnel Zone Plate (Å)	Total Horizontal Angular Acceptance (mradians)
15 - 40	600	3×10^{-3}	10^{11}	1200 - flux in this spot=10^4/sec.	5.0

Optical Configuration

a) **Monochromator**
Single element grazing incidence toroidal grating monochromator; gold laminar grating with 120 Å deep grooves, grating area is 50 mm long by 15 mm wide, sagittal radius is 0.19 meters and meridional radius is 88 meters, toroid focal point at 9 meters from source; dispersion is vertical and negative first order; total deviation is 5.72°; located 3 meters from the source.

b) **Mirror**
Planar mirror (quartz or gold coated or nickel coated types available) for readjusting the beam to the horizontal plane after exiting the monochromator, choice of mirror dependent upon wavelength desired; located 9 meters from the source.

Experimental Apparatus

System capable of introducing soft x-rays into atmosphere outside beam line proper via a 200 μm x 200 μm, 1200 Å thick Si_3N_4 window thus allowing the use of wet sample mounts; spectroscopy chamber for solid or gas phase; contact microscopy/lithography chamber.

Computer System Hardware and Software

PDP 11/23 computer; CAMAC interface; RT-11(v.4) operating system; color monitor; printer; two 10 MB hard disks; dual RX02 floppy disk drives; software for automatic control of monochromator.

April 29, 1987

Beam Line:	U16A
Ring:	VUV
Operational Status:	Construction Operational end 87

Participating Institutions: Cornell U., Sandia National Laboratory, U. of Texas

Local Contact: Thor Rhodin (607)255-4068; Cornell U.

Spokesperson: Thor Rhodin

Research Program: ARUPS, stimulated desorption, XPS, SEXAFS, NEXAFS

Expected Values					
Energy Range (eV)	Grating Type (grooves/mm)	Resolution ($\Delta E/E$)	Flux (phot./sec./ 0.1A/0.05% bw)	Spot Size - focused (mm)	Total Angular Acceptance (mradians)
25 - 190	600 (2m radius)	0.67×10^{-3} @ 100 eV	6×10^{10} @ 100 eV (0.75 GeV)	1.0H x 1.0V	12H x 2V
140 - 600	800 (3.71m radius)	1.1×10^{-3} @ 400 eV	3×10^{10} @ 400 eV (0.75 GeV)	1.0H x 1.0V	12H x 2V
270 - 1000	1200 (5m radius)	0.8×10^{-3} @ 600 eV	4×10^{10} @ 600 eV (0.75 GeV)	1.0H x 1.0V	12H x 2V

Optical Configuration

a) **Mirror No. 1**
Elliptical gold coated Pyrex mirror, length is 96 cm, 2° angle of incidence, 2° angle of deflection, magnification of 1, focuses at 3 meters at the monochromator exit slit in a plane perpendicular to the gratings; located 3.06 meters from the source.

b) **Mirror No. 2**
Bent gold coated elliptical Pyrex mirror, length is 30 cm, focuses 52 cm downstream to monochromator entrance slits; demagnification 7:1.

c) **Monochromator**
Extended range grasshopper (ERG); entrance slit is Codling mirror/slit combination; three gratings installed and interchangeable at UHV; each grating is gold coated silica, holographically formed and ion etched; exit slit is continuously adjustable down to 10 μm.

d) **Mirror No. 3**
Gold coated elliptically refocusing Pyrex mirror focuses beam with a demagnification of 1:1; mirror is located 7.1 meters from the source.

e) **Mirror No. 4**
Flat gold coated Pyrex mirror makes final reflection of the beam onto sample; located 7.5 meters from the source.

Experimental Apparatus

UHV chamber with cylindrical mirror analyzer (for Auger), LEED facility, sputter gun, spherical mirror analyzer (for ARUPS).

Computer System Hardware and Software

DEC LSI 11/73 processor with 0.5 MB main memory; 42 MB Winchester and dual 8" floppy disk drives; serial (RS232) and parallel interfaces; computer interfaced with CAMAC crate; operating system is TSX-plus; software available for automatic monochromator control.

May 1, 1987

Beam Line:	U16B
Ring:	VUV
Operational Status:	Planned Operational by 88

Participating Institutions: Cornell U., Sandia National Laboratory, U. of Texas

Local Contact: Robert Merrill (607)255-7504; Cornell U.

Spokesperson: Robert Merrill

Research Program: Molecular beam scattering, solid state photoemission, soft x-ray spectrocopy

Expected Values					
Energy Range (eV)	Grating Type (grooves/mm)	Resolution ($\Delta E/E$)	Flux (phot./sec.)	Spot Size (mm)	Total Horizontal Angular Acceptance (mradians)
10 - 80					

Optical Configuration

Beam splitter located on U16A takes 20 mradian fan and deflects beam upward directly above U16A toward Seya-Namioka monochromator. Beam is then deflected downward via three mirrors to same focusing point at sample as in U16A.

Experimental Apparatus

This beam line will share experimental apparatus with U16A.

Computer System Hardware and Software

This beam line will share computer equipment with U16A.

May 1, 1987

Beam Line:	U16C
Ring:	VUV
Operational Status:	Construction Operational end 87

Participating Institutions: U. of Texas, Sandia National Laboratory

Local Contact: James L. Erskine (512)471-1464; U. of Texas

Spokesperson: James L. Erskine

Research Program: Angle-resolved photoelectron emission, spin-polarized photoelectron emission, epitaxial metal films

Expected Values					
Energy Range (eV)	Grating Type (grooves/mm)	Resolution ($\Delta\lambda/\lambda$)	Flux (phot./sec. @ 0.1% bw)	Spot Size - focused (mm)	Total Angular Acceptance (mradians)
8 - 40	288 (G3)	3-4 x 10^{-4}	1.7 x 10^{10} (250 mA/750 MeV)	20.0H x 4.0-0.4V	25.0H x 5.0V
20 - 100	822 (G2)	3-4 x 10^{-4}	1.7 x 10^{10} (250 mA/750 MeV)	20.0H x 0.6-0.2V	25.0H x 5.0V
50 - 250	2400 (G1)	3.0 x 10^{-4}	0.43 x 10^{10} (250 mA/750 MeV)	20.0H x 0.5-0.1V	25.0H x 5.0V

Optical Configuration

a) **Mirror No. 1**
Gold coated fused quartz ellipsoidal mirror; 71.1 mm x 121.9 mm x 38.1 mm deep; operates at UHV; images 2225.0 mm downstream from mirror, magnifies by 1.0; 5.0° grazing angle of incidence; adjustable with three point linear (0.01 mm increments) and one rotational (1 mradian increments) mounts about vertical axis; located 2225.0 mm from the source.

b) **Monochromator**
Six meter toroidal grating monochromator with three grating types interchangeable in UHV under normal operating conditions; entrance and exit PSL-design slits adjustable from 20 - 1500 μm; zero order of incidence is 80° for all gratings; gratings are abberation compensated holographic quartz type, G1 is platinum coated, G2 + G3 are gold plated; located 7 meters from the source.

c) **Mirror No. 2**
Gold coated fused quartz ellipsoidal mirror; 50.8 mm x 254 mm x 26.4 mm deep; input focal length of 2100 mm from monochromator exit; mirror to sample position 0.6 meters downstream; grazing angle of incidence is 5.0°; same adjustments as Mirror No. 1; located 13.0 meters from the source.

Experimental Apparatus

High resolution angle-resolved electron energy analyzer (designed and built by J.L. Erskine), mounted on a two-axis goniometer (Θ_V = +90 to -130°, Θ_H = +30 to -180°), resolving power is 0.01 ($\Delta E/E$), angular resolution ($\Delta\Theta$) ± 1.5°; UHV sample introduction and prep chambers with in-vacuum transfer and LEED/Auger facilities; MBE sample preparation capabilities.

Computer System Hardware and Software

PDP-11/23 computer with 30 MB hard disk drive and dual 5 1/4" floppies of 400K each; RSX-11M operating system, CAMAC modules; Tektronix graphics terminal; graphics plotter; complete data acquisition and analysis software package written by Andrew Donoho.

April 30, 1987

C. The X-Ray Storage Ring and Beam Lines

The following items are listed in this section:

- a list of parameters describing the X-ray ring (see Table 4);
- a plot indicating the energy ranges used in the research at the various X-ray beam lines (see Figure 4);
- single page descriptions for each of the X-ray beam lines.

Further information regarding the X-ray ring and associated beam lines may be obtained by contacting:

Dr. Roger W. Klaffky
X-Ray Research Operations Manager
National Synchrotron Light Source
Building 510E
Brookhaven National Laboratory
Upton, NY 11973
(516)282-4974

X-Ray Beam Line Descriptions

Each beam line description is dated to indicate when the configuration described existed. These configurations are expected to change over time. A number of points are explained below.

1. Operational Status:
   a. Operational - beam line is actively used in research;
   b. Commissioning - beam line is built and is being run for the sole purpose of detecting flaws in the configuration;
   c. Construction - beam line is being assembled;
   d. Planned - beam line design is completed but construction has not yet begun;
   e. Conceptual - pre-design stage.
2. Local Contact: individual(s) usually available at the beam line, their telephone number and the location of that number.
3. Spokesperson: individual(s) responsible for the beam line research program, their telephone number and the location of that number.
4. Research Program: describes only broad or general categories of research; specifics should be discussed with the beam line personnel.
5. Optical Configuration: listed in the order in which components appear going downstream along the beam line.
6. Experimental Apparatus: equipment normally available to outside users.
7. Computer System Hardware and Software: equipment normally available to outside users.
8. The following X-ray beam lines are not described below and are used for NSLS R&D as well as beam line diagnostics: X12A, X13, X27, X28, X29, X30.
9. Abbreviations: EXAFS = extended X-ray absorption fine structure; SEXAFS = surface EXAFS.

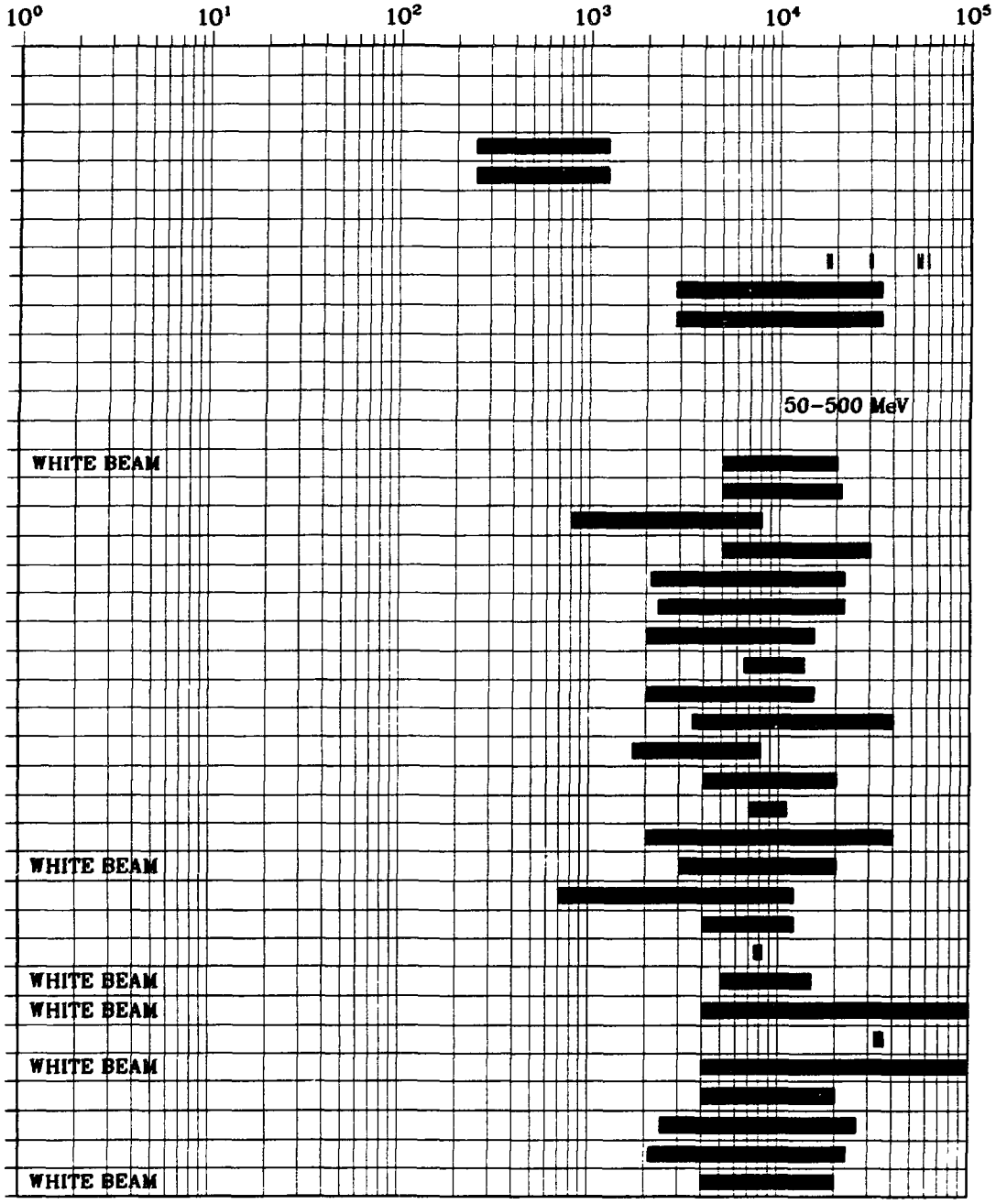
Table 4

X-Ray Storage Ring Parameters as of June 1987

Parameters	X-Ray Storage Ring
Normal Operating Energy	0.75 - 2.5 GeV
Design Current	0.5 amp (1.9×10^{12} e^-)
Circumference	170.1 meters
Number of Beam Ports of Dipoles	30
Number of Insertion Devices	5
Maximum Length of Insertion Devices	< 4.50 meters
$\lambda_c(E_c)$ at 1.22 T (B)	2.48 Å (5 keV)
λ_c (E_c) at 6.0 T (W)	0.50 Å (25 keV)
$B(\rho)$	1.22 Tesla (6.875 meters)
Electron Orbital Period	567.7 nanoseconds
Damping Times (0.7 GeV)	$\tau_x = \tau_y = 6$ msec; $t_\epsilon = 3$ msec
Touschek (0.7 GeV, 1A)	$\geq$ 0.6 hrs ($\hat{v}_{RF} = 800$ kV)
Touschek (2.5 GeV, 0.5A)	$\geq$ 8 hrs (same)
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	0.0065
R.F. Frequency	52.88 MHz
Radiated Power for Bending Magnets	252 kW/0.5 amp of Beam
R.F. Peak Voltage	800 kV
Design R.F. Power	500 kW
ν_s (Synchrotron tune)	0.002
Natural Energy Spread (σ_ϵ/E)	8.2×10^{-4}
Natural Bunch Length (2σ)	10.5 cm
Horizontal Damped Emittance (ϵ_x)	8.0×10^{-8} meter-radian
Vertical Damped Emittance (ϵ_y)	8.0×10^{-10} meter-radian
Power per Horizontal milliradian, 0.5A	40 watts
Source Size: σ_h, σ_v	$\sim$ 0.35 mm, $\sim$ 0.15 mm

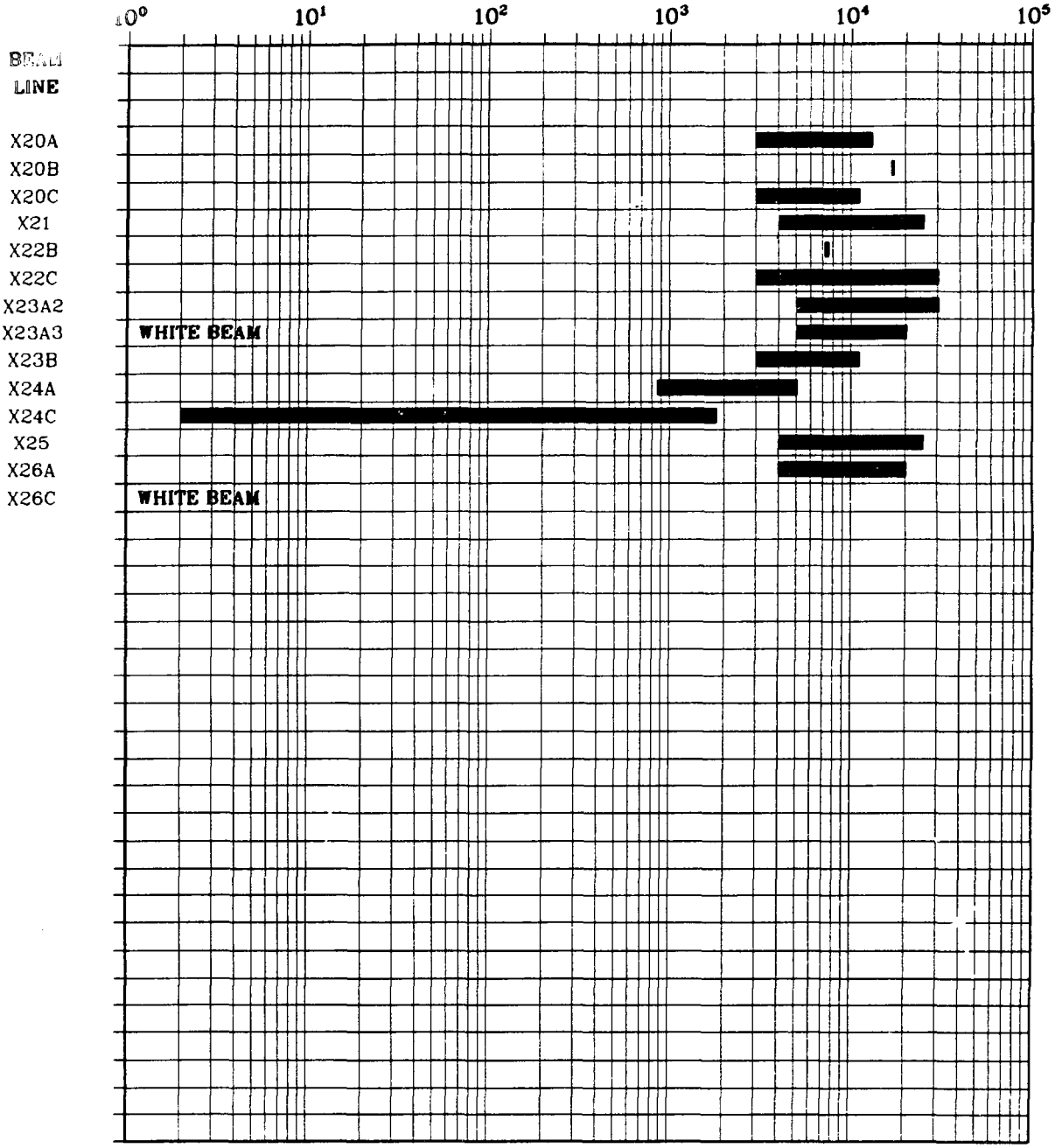
Source of Data: NSLS Parameters, January 1983, compiled by A. van Steenbergen; updated values provided by Ben Craft (NSLS).

Figure 4: X-Ray Beam Line Energy Ranges (eV)



August 1987

X-Ray Beam Line Energy Ranges (eV) – Cont'd.



August 1987

Beam Line:	X1A
Ring:	X-Ray
Operational Status:	Construction Operational Summer 88

Insertion Device Team: NSLS, SUNY at Stony Brook, IBM, Lawrence Berkeley Laboratory

Local Contact: Harvey Rarback (516)282-5601, 3758; BNL

Spokesperson: Harvey Rarback

Research Program: Soft x-ray imaging

Expected Values					
Wavelength Range (Å)	Source	Grating Type (grooves/mm)	Resolving Power ($\lambda/\Delta\lambda$)	Spatially Coherent Flux (phot./sec./0.1% bw)	Spot Size Focused with Fresnel Zone Plate (Å)
10 - 50	Soft x-ray undulator - 37 periods - 8 cm period	700	300 - 3000	10^{12}	500 flux in this spot = 10^{8}/sec

Optical Configuration

a) **Mirror**
Planar high energy cutoff mirror with one surface strip of beryllium and one of gold; a jack device positions either strip into or out of the beam path; located 13 meters from the undulator source.

b) **Pinhole Collimator**
Located between mirror and monochromator grating to produce a spacially coherent source for imaging; pinhole diameter ranges from 50 - 500 μm; located 16 meters from the undulator source.

c) **Monochromator**
Single toroidal grating monochromator; grating is gold coated silicon carbide; UHV up to and including exit slit; located 18 meters from the undulator source.

d) **Fresnel Zone Plate**
Testing various types and aiming for 100 Å resolution; located 20 meters from the undulator source.

Experimental Apparatus

A variety of imaging modes will be used including scanning x-ray microscopy, x-ray holography, soft x-ray diffraction and contact microscopy; these will use primarily biological specimens (possibly wet, in or out of air).

Computer System Hardware and Software

Data analysis and image display using MicroVAX II with 600 MB hard disk; high resolution color image display; beam line control and data acquisition using PDP 11/73 and CAMAC interface.

May 8, 1987

Beam Line:	X1B
Ring:	X-Ray
Operational Status:	Commissioning Operational Summer 88

Insertion Device Team: Exxon Research and Engineering

Local Contact: Wolfgang Eberhardt (201)730-2567; Exxon (516)282-5701; BNL

Spokesperson: Wolfgang Eberhardt

Research Program: Soft x-ray spectroscopy

Expected Values					
Wavelength (Å)	Source	Gratings (grooves/mm)	Resolution	Flux (phot./sec.)	Spot Size - focused (mm)
10 - 50	same as X1A	~800 (others available in the future)	<100 meV @ 300 eV <500 meV @ 500 eV		2H x 1V

Optical Configuration

a) **Mirror No. 1**
Cylindrical focusing aluminum mirror coated with electroless nickel and gold; 2.5° angle of incidence; water-cooled; focuses undulator source horizontally onto sample; located 14.2 meters from the source.

b) **Mirror No. 2**
Cylindrical focusing aluminum mirror coated with electroless nickel and gold; 2.5° angle of incidence; 5:1 demagnification; focuses undulator source vertically onto entrance slit of monochromator; located 14.45 meters from the source.

c) **Monochromator**
Cylindrical grating monochromator with moveable exit slit; optical glass gold coated cylindrical or spherical gratings, total deflection angle is 6.6°, up to six gratings interchangeable at UHV, holographically etched.

Experimental Apparatus

Three different experimental setups for photoemission of solids; one system for photoemission and ion mass spectroscopy of gasses. For details contact the Spokesperson.

Computer System Hardware and Software

PDP 11/73 with RSX operating system, RL02 disk drive, RC25 disk system; CAMAC crate; AT&T PC6300 for monochromator and undulator control; HP plotter with DEC system; printer.

May 4, 1987

Beam Line:	X2A
Ring:	X-Ray
Operational Status:	Design Stage

Pariticipating Institutions: Argonne National Laboratory, Brooklyn College of the CUNY, NSLS, North Carolina State U., Northwestern U., Standard Oil, U. of Michigan

Local Contact: Mati Bloch (516)282-5602, 3641; BNL

Spokesperson: Gopal Shenoy (312)972-5537; Argonne National Laboratory

Research Program: Scattering, small angle scattering, diffraction

Further details will be available in the future.

August 6, 1987

Beam Line:	X2B
Ring:	X-Ray
Operational Status:	Design Stage

Pariticipating Institutions: Argonne National Laboratory, Brooklyn College of the CUNY, NSLS, North Carolina State U., Northwestern U., Standard Oil, U. of Michigan

Local Contact: Timothy Morrison (516)282-5602; BNL
(312)972-5539; Argonne National Laboratory

Spokesperson: Gopal Shenoy (312)972-5537; Argonne National Laboratory

Research Program: Time and space resolved dispersive x-ray spectroscopy

Further details will be available in the future.

August 6, 1987

Beam Line:	X3A1
Ring:	X-Ray
Operational Status:	Planned Operational in 88

Participating Institutions: State University of New York

Local Contact: Prof. James C. Phillips (516)282-5603, 3770; BNL

Spokesperson: Prof. Philip Coppens (716)831-3911; SUNY at Buffalo

Research Program: Short wavelength crystallography, diffraction and scattering

Expected Values				
Energy Range (keV)	Crystal Type	Flux @ 500 mA, 2.5 GeV (phot./sec./mrad/0.1% bw)	Spot Size (mm)	Total Horizontal Angular Acceptance (mradians)
17.5 [52.5]	Ge(111) [Ge(333)]	$2 - 4 \times 10^{11}$	H $\leq$ 0.4 V fixed @ 2	1.8 (max)
29.7 [59.4]	Si(220) [Si(440)]	4×10^{10}	H $\leq$ 0.4 V fixed @ 2	1.8 (max)
18.2 [54.6]	Si(111) [Si(333)]	1×10^{11}	H $\leq$ 0.4 V fixed @ 2	1.8 (max)

Optical Configuration

a) **Monochromator**

Single bent triangular crystal to monochromatize the beam and focus it in the horizontal with a sideways diffraction (installed in X3A2 monochromator housing) ; up to 5 mradians available for interception; 2Θ fixed at 12.0°; horizontal focusing variable to a minimum of 0.5x of source size; energy resolution ($\Delta E/E$) varies with focal spot chosen; sample at 11.1 meters from source; monochromator located 7.2 meters from the source.

b) **Mirror**

Flat bent mirror (in conceptual design stage) for vertical variable focusing and harmonic rejection; focusing capabilities from ~0.2 - 2.0 mm; post-monochromator location not yet defined.

Experimental Apparatus

Radiation hutch; diffractometer similar to Huber in X3A2; cryostats (down to 10° K); high temperature and high pressure cells.

Computer System Hardware and Software

Undefined as yet.

May 7, 1987

Beam Line:	X3A2
Ring:	X-Ray
Operational Status:	Operational

Participating Institutions: State University of New York

Local Contact: Prof. James C. Phillips (516)282-5603, 3770; BNL

Spokesperson: Prof. Philip Coppens (716)831-3911; SUNY at Buffalo

Research Program: Diffractometry, x-ray spectroscopy, crystallography, scattering, small angle scattering

Energy Range (keV)	Crystal Type	Resolution - unslitted ($\Delta E/E$ @ 9 keV)	Flux (photons/sec.)	Spot Size - focused - FWHM (mm)	Total Horizontal Angular Acceptance (mradians)
4 - 13 (foc.) 4 - 27 (unfoc.)	Si(111)	5.9×10^{-4}	3.4×10^{11} @ 6 - 9 keV (133 mA, 2.523 GeV)	0.90 ± 0.02H x 0.60 ± 0.02V	7.0
4.6 - 13 (foc.) 4.6 - 34 (unfoc.)	Si(220)	3.5×10^{-4}	1.4×10^{10} @ 8 keV (50 mA, 2.4 GeV)	1.5H x 1.5V	7.0
2.8 - 13 (foc.) 2.8 - 20 (unfoc.)	Ge(111)	6.3×10^{-4}	1×10^{13} (theoret.)		7.0

Optical Configuration

a) **Monochromator**
Double flat crystal monochromator with rapid tunability and fixed exit geometry; 7.4 meters from the source.

b) **Mirror**
1:1 gold coated doubly focusing bent toroidal quartz mirror; 600 mm long x 60 mm wide with a 60 mm radius; incident angles between 5.7 and 8.2 mrad; adjustable focal point from 15 to 22 meters; radiation cutoff at 9.7 keV for 15 meters and at 14 keV for 22 meters; located 8.6 meters from the source.

Experimental Apparatus

Radiation hutch; four-circle Huber diffractometer with 0.001° precision and crystal analyzer; x-ray spectroscopy detectors; xyz table (~1000 lbs. capacity); cryostats; high temperature and high pressure cells; optical bench; linear position sensitive detector; motor driven translation stages with 0.1 μm resolution; sample chambers.

Computer System Hardware and Software

LSI-11/23 computer; CAMAC modular interface; disk and tape storage; hard copy and VDU graphics terminals; plotter; RSX11M multiuser operating system; comprehensive data collection and analysis software package.

May 7, 1987

Beam Line:	X3B
Ring:	X-Ray
Operational Status:	Operational

Participating Institutions: State University of New York

Local Contact: Prof. James C. Phillips (516)282-5603, 3770; BNL

Spokesperson: Prof. Philip Coppens (716)831-3911; SUNY at Buffalo

Research Program: X-ray spectroscopy, surface physics

Energy Range (keV)	Crystal Type	Resolution - unslitted ($\Delta E/E$ @ 9 keV)	Flux (photons/sec./2 mrad)	Spot Size - 2 mrad unfocused (mm)	Total Horizontal Angular Acceptance (mradians)
4 - 27	Si(111)	5.9×10^{-4}	1×10^{12} (500 mA, 2.5 GeV)	20H x 2V	8
4.6 - 34	Si(220)	3.5×10^{-4}	2×10^{12} (500 mA, 2.5 GeV)	20H x 2V	8
2.8 - 20	Ge(111)	6.3×10^{-4}	5×10^{12} (500 mA, 2.5 GeV)	20H x 2V	8

Optical Configuration

Monochromator

Double crystal monochromator; first crystal is flat; sagittal focussing of second crystal is planned for the future; fixed exit geometry; 0° - 89° Bragg angle range; located 10.4 meters from the source.

Experimental Apparatus

Radiation hutch; x-ray spectroscopy detectors; cryostats (down to 10° K); high temperature and high pressure cells. A surface science chamber is located downstream and outside of the radiation hutch and is equipped with a sample manipulator, surface cleaning, surface characterization e.g. photoemission, surface diffraction and x-ray standing wave capability with synchrotron radiation.

Computer System Hardware and Software

LSI-11/23 computer using RSX11M multiuser system; CAMAC module interface ; floppy disks; VDU graphics terminal; hardcopy plotter and tape drive shared with X3A2; software as for X3A2.

May 7, 1987

Beam Line:	X4A
Ring:	X-Ray
Operational Status:	Conceptual Operational by 1989

Participating Institutions: Howard Hughes Medical Institute

Local Contact: Jean-Louis Staudenmann (516)282-5604; BNL

Spokesperson: Wayne A. Hendrickson (212)305-3456; Columbia University

Research Program: Multiwavelength anomalous diffraction analysis of crystalline biological macromolecules

Optical Configuration

The x-ray optics will include a double crystal monochromator with a water-cooled flat first crystal and a sagittally focused second crystal positioned for a fixed exit beam condition. A mirror system for additional focussing and harmonic rejection will also be designed.

Experimental Apparatus

A Radiation hutch; single crystal goniometer with constant temperature control; an area detector system will be installed for efficient data collection, but a single counter capability will also be available.

Computer System Hardware and Software

The computer systems for controlling the beam line and data acquisition system have not yet been selected.

August 6, 1987

Beam Line:	X4C
Ring:	X-Ray
Operational Status:	Conceptual Operational by 1989

Participating Institution: Howard Hughes Medical Institute

Local Contact: Jean-Louis Staudenmann (516)282-5604; BNL

Spokesperson: Wayne A. Hendrickson (212)305-3456; Columbia University

Research Program: Diffraction measurements from biological macromolecules

Optical Configuration

The x-ray optics will include a bent single crystal monochromator followed by a focussing mirror. The monochromator design will permit rapid and simple tuning.

Experimental Apparatus

Radiation hutch; diffraction equipment with rotation and precession photography capabilities; an imaging-plate area detecor is in planning.

Computer System Hardware and Software

The computer systems for controlling the beam line and data acquisition system have not yet been selected.

August 6, 1987

Beam Line:	X5
Ring:	X-Ray
Operational Status:	Commissioning Operational in 88

Participating Institutions: BNL - Physics Department

Local Contact: Andrew Sandorfi (516)282-7951; BNL

Spokesperson: Andrew Sandorfi

Research Program: Laser electron gamma source (LEGS), medium energy nuclear physics.

Expected Values					
Energy Range (MeV)	Resolution ΔE (MeV)	Ring Energy (GeV)	Target Areas	Distance from Center of Straight Section (m)	Spot Size (mm)
50 - 180	–	2.5	1	25	22H x 7V
180 - 350	5	2.5	2	36	30H x 9V
200 - 500	8	3.0	3	43	37H x 12V

Operation

Gamma ray beams are produced by Compton backscattering of laser light from electrons circulating in the 2.5 - 3.0 GeV X-ray storage ring. Fluxes of $>10^7$ γ/sec (200 mA, 2.5 GeV) have been obtained but vary depending on the laser used, electron current and ring energy. Photons will be tagged by detecting the scattered electrons in a spectrometer incorporated into the storage ring (tagging efficiency = 100%). Linear and circular polarization of >75% are available.

Experimental Apparatus

High energy gamma spectrometer; liquid hydrogen/deuterium target; $\pi^{\pm}$ magnetic spectrometer - 25 to 200 MeV pions (available 1989).

Computer System Hardware and Software

MircoVAX II computer with a 70 MB disk and two Eagle 340 MB disk drives, and a CAMAC based data collection system using the LANL "Q" system; Universe 68,000 computer with 35 MB storage using UNIX-based multiuser operating system; tape drive, Transiac graphics terminal; data acquisition software based on CAMAC.

May 28, 1987

Beam Line:	X6A
Ring:	X-Ray
Operational Status:	Conceptual Operational in 89

Participating Institutions: Exxon Research and Engineering Company
Local Contact: Kevin D'Amico (516)282-2065; BNL
Spokesperson: Kevin D'Amico (201)730-2891; Exxon
Research Program: X-ray tomography

Following are rough estimates.

Optical Configuration

Mirror and monochromator configuration to allow acceptance of maximum amount of horizontal radiation fan and allow tunability of energy resolution.

Experimental Apparatus

Radiation hutch (to be designed).

Computer System Hardware and Software

System for manipulating beam line hardware (to be specified).

May 29, 1987

Beam Line:	X7A
Ring:	X-Ray
Operational Status:	Operational

Participating Institutions: NSLS, BNL - Physics Dept., Mobil, U. of Pennsylvania, State University of New York, Alfred U., Allied-Signal, Dupont, Carnegie Institute of Washington, Union Carbide, U. of California at Santa Barbara

Local Contact: David Cox (516)282-5607, 3818; BNL

Spokesperson: David Cox

Research Program: Structural characterization by powder diffraction techniques

Energy Range (keV)	Crystal Type	Resolution ($\Delta E/E$)	Flux at Sample (photons/sec.)	Beam Size - unfocused (mm)	Total Horizontal Angular Acceptance (mradians)
5 - 45	White Beam	Semiconductor detector $1 \rightarrow 2 \times 10^{-2}$ Crystal analyzer $10^{-3} \rightarrow 10^{-2}$	5×10^{13}/keV @ 10 keV 4×10^{12}/keV @ 20 keV 5×10^{11}/keV @ 30 keV 7×10^{10}/keV @ 40 keV (100 mA, 2.5 GeV)	5.0H x 2.5V	2
5 - 20	Ge(111,220)	$2 \times 10^{-4} \rightarrow 10^{-3}$	2×10^{10} @ 8 keV (100 mA, 2.5 GeV)	5.0H x 2.5V	2

Optical Configuration

a) **White Beam Mode**
Sample located 16 meters from the source; beam size defined by remote-controlled variable slits with resolution of 2.5 μm yielding beam dimensions up to 20 mm horizontal and 2.5 mm vertical.

b) **Monochromator Mode**
Single flat crystal monochromator scattering in horizontal plane; sample scattering in vertical plane; located in hutch 16 meters from the source (double crystal scattering in vertical plane available by start of 1988).

Experimental Apparatus

Radiation hutch; two circle Huber Θ - 2Θ goniometer system with vertical axis with xyz translations and two horizontal arcs; 2Θ goniometer carries a horizontal arm on which is mounted a four circle Huber diffractometer scattering in the vertical plane with an analyzer table and detector arm; various analyzer crystals available e.g. Ge(111), Ge(220), Ge(400), InSb(111), Si(111), graphite(004), LiF(200), quartz(101); ionization chamber; scintillation detectors; Ge semiconductor detector; DISPLEX cryostat (20° - 300°K) available end of 1987; Canberra Series 85 MCA (8K channels); furnaces available by end of 1987.

Computer System Hardware and Software

LSI 11/73 computer; 300 MB Winchester; RX02 disk storage; 9-track magnetic tape drive; RSX11M operating system; CAMAC interface; Visual Effects 550 graphics terminal; LA50 printer; library of powder diffraction analysis programs available.

May 14, 1987

Beam Line:	X7B
Ring:	X-Ray
Operational Status:	Operational

Participating Institutions: NSLS, BNL - Chemistry Dept., U. of Pittsburgh, Swedish Research Council, Mobil Research and Development Corp.

Local Contact: Åke Kvick (516)282-5707, 4381; BNL

Spokesperson: Åke Kvick

Research Program: Crystallography, wide angle scattering

Energy Range (keV)	Crystal Type	Resolution ($\Delta E/E$)	Flux (photons/sec.)	Spot Size - focused (mm)	Total Horizontal Angular Acceptance (mradians)
5 - 21	Si(111/220)	2×10^{-4}	6×10^{11} @ 10 keV (500 mA, 2.5 GeV)	0.3 x 0.3 mm^2 1% variation for intensity	2

Optical Configuration

a) **Mirror No. 1**
Spherical rhodium coated silicon carbide mirror; for vertical focusing; grazing angle of 3 mradians; located 5 meters from the source (to be installed at a future date).

b) **Monochromator**
Double flat crystal monochromator in ultra-high vacuum; first crystal is water-cooled; crystal movement in two ranges from 8.5° - 15° and from 13.5° - 70° Bragg angle; piezoelectric adjustment of second crystal; located 8 meters from the source.

c) **Mirror No. 2**
Cylindrical aluminum mirror with nickel plating coated by rhodium; mirror bender for horizontal focusing of 2 mradians; grazing angle of 3 mradians; optics designed to give a beam intensity of 1% homogeneity over an area of 0.3 x 0.3 mm^2 at 22 meters from source; located 13 meters from the source.

Experimental Apparatus

Radiation hutch; four circle Huber diffractometer with crystal analyzer; xyz lift table with 500 - 800 lbs. capacity; oscillation camera with cooling down to 190°K; DISPLEX two-stage refrigerator (10° - 400°K); diffusion pump station; scintillation and ionization detectors; linear detector with time-slicing capability in μsec regime under development.

Computer System Hardware and Software

PDP 11/23 computer; RSX11M operating system; Tektronix 4006 graphics terminals; printers; 9-track magnetic tape; RL02 and RX02 removable storage; 140 MB of fixed disk storage; MicroVAX II, 130 MB of disk storage, 6 MB of memory; Ethernet connected to PDP 11/23 and its peripherals; complete data acquisition and analysis software written in FORTRAN.

May 14, 1987

Beam Line:	X8A
Ring:	X-Ray
Operational Status:	Commissioning Operational by Spring 88

Participating Institutions: Los Alamos National Laboratory, Sandia National Laboratory, Lawrence Livermore National Laboratory, U. of California

Local Contact: Randy Alkire (516)282-5503, 5520; BNL

Spokesperson: Walter J. Trela (505)667-1674; Los Alamos National Laboratory
Roger J. Bartlett (505)667-5923; Los Alamos National Laboratory

Research Program: Photoelectron spectroscopy, photoion spectroscopy

Expected Values					
Energy Range (keV)	Crystal Type	Resolution ($\Delta E/E$)	Flux (photons/sec.)	Spot Size - unfocused (mm)	Total Horizontal Angular Acceptance (mradians)
0.8 - 8	Si(111) Ge(111) InSb(111) Synthetic Mica(001)	10^3	5×10^{10} @ 5 keV (100 mA, 2.5 GeV)	0.5H x 0.5V	3

Optical Configuration

a) **Mirror No. 1**
Nickel coated fused quartz cylindrical mirror, bent to form an ellipse, 70 mm wide x 700 mm long; 10 mradian incidence angle; mirror position and curvature controlled by stepping motors; located 7.5 meters from the source.

b) **Monochromator**
Double flat crystal monochromator; angular range 71° to 14° (depending on crystal size); single stepping motor control of Bragg angle; differential screw fine tuning (detuning); located 19 meters from the source.

Experimental Apparatus

User supplied apparatus must be UHV compatible.

Computer System Hardware and Software

DEC MicroVAX II computer; VMS operating system; nine-track magnetic tape drive; CAMAC interface.

May 13, 1987

Beam Line:	X8C
Ring:	X-Ray
Operational Status:	Commissioning Operational by Spring 88

Participating Institutions: Los Alamos National Laboratory, Sandia National Laboratory, Lawrence Livermore National Laboratory, U. of California

Local Contact: Randy Alkire (516)282-5503, 5520; BNL

Spokesperson: Walter J. Trela (505)667-1674; Los Alamos National Laboratory

Research Program: EXAFS, diffraction

Expected Values					
Energy Range (keV)	Crystal Type	Resolution ($\Delta E/E$)	Flux (photons/sec.)	Spot Size (mm)	Total Horizontal Angular Acceptance (mradians)
5 - 20	Si(111)	1.3×10^{-4}	10^{11} @ 10 keV (100 mA, 2.5 GeV)	~2H x 2V (focused)	4.0
15 - 30	Si(220)	6×10^{-5}	10^{11} @ 20 keV (100mA, 2.5 GeV)	140H x 5V (unfocused)	4.0

Optical Configuration

a) **Mirror**
Bent flat rhodium coated fused quartz collimating mirror, 80 mm wide x 900 mm long; high energy cutoff is 20 keV; adjustable position; may be moved from incident beam path; located 9 meters from the source.

b) **Monochromator**
Convertible from a two to a four crystal mode, located 12 meters from the source.

1) **Two Crystal Mode**
Energy resolution for Si(111) and Si(220) = 2×10^{-4} and somewhat higher flux than above; beam position is not fixed but moves vertically.

2) **Four Crystal Mode**
Parameters given in the above table; fixed beam position.

Experimental Apparatus

Radiation hutch; ion chambers for detecting I_o, I and fluorescence; lift table for sample adjustment; six circle goniometer; slit and filter system for fluorescence detection.

Computer System Hardware and Software

DEC MicroVAX II computer; VMS operating system; CAMAC interface; Ethernet connection to Applied Math Dept.

May 13, 1987

Beam Line:	X9A
Ring:	X-Ray
Operational Status:	Operational

Participating Institutions: National Biostructures Research Resource

Local Contact: Syed Khalid (516)282-5609; BNL

Spokesperson: Grant Bunker (215)386-1912; University City Science Center

Research Program: EXAFS

Energy Range (keV)	Crystal Type*	Resolution @ 8 keV** (eV)	Flux (phot./sec.) @ 8 keV 200 mA, 2.5 GeV - full vert. aperture	Spot Size - unfocused (mm)	Total Angular Acceptance (mradians)
2.1 - 11.4	Si(111)	3 (2)	1×10^{13}	200H x 5V	12.5H x 0.3V
3.4 - 18.8	Si(220)	2 (1)	3×10^{12}	200H x 5V	12.5H x 0.3V
4.0 - 21.8	Si(311)	2 (0.7)	2×10^{12}	200H x 5V	12.5H x 0.3V

* Not all crystals available at this time.

** For 2 mm vertical aperature. Values in parentheses are with collimating mirror and full vertical aperture.

Optical Configuration

a) **Mirror No. 1**
Planar cylindrically bent aluminum collimating mirror plated with nickel, for increasing the energy resolution at large vertical apertures; independent adjustment of mirror angle and focal length; 650 mm x 150 mm; located 8 meters from the source (planned).

b) **Monochromator**
Double flat crystal monochromator with fixed exit geometry; Bragg angle range is 10° - 71°; rapid crystal exchange; novel water-cooling design; stationary axis for first crystal, second crystal linked in parallel with first; operates at high vacuum (10^{-7} Torr); located 12 meters from the source.

c) **Mirror No. 2**
Planar cylindrically bent aluminum vertically focusing mirror plated with nickel, for elimination of higher harmonics and producing a line focus in hutch (16 meters from source); 800 mm x 200 mm; independent adjustment of mirror angle and focal length; located 13.5 meters from the source.

Experimental Apparatus

Radiation hutch; low temperature sample chamber (-120°C); flow apparatus; arrays of PMT's with fast plastic scintillators for photon counting or with high efficiency phosphors for current mode; Stern-Heald fluorescent radiation ion chamber.

Computer System Hardware and Software

PDP 11/23+ computer with CAMAC interface for beam line control, support instrumentation control and data acquisition, 512K memory, two RL02 disk drives with 10MB each, using RSX-11M operating system; EXAFS data analysis software; VAX-11/730 using VMS operating system for data analysis.

June 4, 1987

Beam Line:	X9B
Ring:	X-Ray
Operational Status:	Planned
	Operational by 88

Participating Institutions: National Biostructures Research Resource

Local Contact: Syed Khalid (516)282-5609; BNL

Spokesperson: Kent Blasie (215)898-6208; U. of Pennsylvania

Research Program: Scattering, diffraction

Expected Values					
Energy Range (keV)	Crystal Type	Resolution @ 8 keV* (eV)	Flux (phot./sec) @ 8 keV** 200 mA, 2.5 GeV	Spot Size - point focused (mm)	Total Horizontal Angular Acceptance (mradians)
2.4 - 11.4	Si(111)	3 (2)	2×10^{12}	0.8H x 0.3V	15 (max.)
3.9 - 18.6	Si(220)	2 (1)	8×10^{11}	@ 20 meters	
4.6 - 21.8	Si(311)	2 (0.7)	4×10^{11}	from source	
2.3 - 10.9	Ge(111)	4 (3)	4×10^{12}		
3.7 - 17.8	Ge(220)	2 (1)	1.5×10^{12}		

Practical lower limit of energy is 3.5 keV due to absorption by Be window.

* For 2 mm vertical aperture. Values in parentheses are with collimating mirror and full vertical aperture.

** Using 5 mrad horizontal and full vertical aperture.

Optical Configuration

a) **Mirror No. 1**
Planar cylindrically bent aluminum collimating mirror plated with nickel, for increasing the energy resolution at large vertical apertures; independent adjustment of mirror angle and focal length; 650 mm x 150 mm; located 8 meters from the source.

b) **Monochromator**
Double crystal monochromator, first crystal is flat and located at same level as X9A monochromator; second crystal is horizontally focusing and located 2 meters above first crystal; crystals operate independently with separately controlled axes; located 10 meters from the source (first crystal).

c) **Mirror No. 2**
Planar cylindrically bent aluminum vertically focusing mirror plated with nickel, for elimination of higher harmonics and for producing a point focus into hutch at 20 meters from source; independent adjustment of mirror angle and focal length; mirror located 16.5 meters from the source.

Experimental Apparatus

Radiation hutch located 2 meters above X9A beam line; four circle diffractometer with 2 meter long 2Θ arm capable of supporting a SIT-TV detector (approx. 100 lbs.).

Computer System Hardware and Software

PDP 11/23+ computer with CAMAC interface for beam line control, support instrumentation control and data acquisition, 512K memory, two RL02 disk drives with 10MB each, using RSX-11M operating system; VAX-11/730 using VMS operating system for data analysis.

June 4, 1987

Beam Line:	X10A
Ring:	X-Ray
Operational Status:	Operational

Participating Institutions: Exxon Research and Engineering

Local Contact: Kevin D'Amico (516)282-5610, 2065; BNL (201)730-2891; Exxon

Spokesperson: David E. Moncton (516)282-2741; BNL (201)730-2384; Exxon

Research Program: Scattering, small angle scattering, diffraction, crystallography

Energy Range (keV)	Crystal Type	Resolution ($\Delta E/E$)	Flux (photons/sec.)	Spot Size - focused (mm)	Total Horizontal Angular Acceptance (mradians)
2 - 15.2	Si(111)	6×10^{-4}	3×10^{11} @ 10 keV (70 mA, 2.5 GeV)	0.8H x 0.6V	3
2 - 15.2	Ge(111)	6×10^{-4}	$\sim 10^{12}$ (theoret.) @ 10 keV (70 mA, 2.5 GeV)	0.8H x 0.6V	3

Optical Configuration

a) **Mirror**
Platinum coated fused silica toroidal mirror for 1:1 focusing at sample located 24 meters from source; sagittal radius is 68.4 mm, meridional radius is 2100 meters; grazing angle of incidence is 5.7 mradians; mirror may be lowered away from the incident beam path; located 12 meters from the source.

b) **Monochromator**
Double flat crystal monochromator (Golovchenko type); piezoelectric driver with feedback keeps crystals in parallel alignment; crystal movement ranges from 7° - 68° Bragg angle; located 22.5 meters from the source.

- vertical and horizontal slits located before mirror and monochromator may be positioned in 3 μm steps.
- a set of six attenuators can be remotely inserted into the beam after the monochromator.

Experimental Apparatus

Radiation hutch; six circle Huber diffractometer; ion chambers; Bicron scintillation detectors.

Computer System Hardware and Software

PDP 11/24 computer; dual RL02 disk drive; LA-100 DECwriter; VT100 terminal; Selanar 100XL; HP printer/plotter; data phone; SUPER Software is used to drive the diffractometer.

May 4, 1987

Beam Line:	X10B
Ring:	X-Ray
Operational Status:	Operational

Participating Institutions: Exxon Research and Engineering

Local Contact: Kevin L. D'Amico (516)282-5610, 2065; BNL (201)730-2891; Exxon

Spokesperson: David E. Moncton (516)282-2741; BNL (201)730-2384; Exxon

Research Program: Crystallography, scattering

Energy Range (keV)	Crystal Type	Resolution ($\Delta E/E$)	Flux (photons/sec.)	Spot Size - focused (mm)	Total Horizontal Angular Acceptance (mradians)
6.5 - 13.5	Si(111)	6×10^{-4}	2×10^{11} @ 11 keV (70 mA, 2.5 GeV)	1H x 1V	2

Optical Configuration

a) **Mirror**
Platinum coated Zerodur flat mirror bent to focus in the vertical; mirror is located 14 meters from the source and has a focal point at 18 meters from the source.

b) **Monochromator**
Bent crystal monochromator with Si(111) crystals asymmetrically cut to collect the horizontal and focus it 18 meters from the source.

Experimental Apparatus

Radiation hutch; six circle Huber diffractometer; ion chambers; Bicron scintillation detectors.

Computer System Hardware and Software

PDP 11/24 computer; dual RL02 disk drive; LA-100 DECwriter; VT100 terminal; Selanar 100XL; HP printer/plotter; data phone; SUPER Software is used to drive the diffractometer.

May 4, 1987

Beam Line:	X10C
Ring:	X-Ray
Operational Status:	Construction Operational Spring 88

Participating Institutions: Exxon Research and Engineering

Local Contact: Kevin D'Amico (516)282-5610, 2065; BNL (201)730-2891; Exxon

Spokesperson: David E. Moncton (516)282-2741; BNL (201)730-2384; Exxon

Research Program: EXAFS

Expected Values					
Energy Range (keV)	Crystal Type	Resolution ($\Delta E/E$)	Flux (photons/sec.)	Spot Size - focused (mm)	Total Horizontal Angular Acceptance (mradians)
2 - 15.2	Si(111)	6×10^{-4}	3×10^{11} @ 10 keV (70 mA, 2.5 GeV)	0.8H x 0.6V	3
2 - 15.2	Ge(111)	6×10^{-4}	$\sim 10^{12}$ @ 10 keV (70 mA, 2.5 GeV)	0.8H x 0.6V	3

Optical Configuration

a) **Mirror**
Platinum coated fused silica toroidal mirror for 1:1 focusing at sample location 20.5 meters from source; sagittal radius is 68.4 mm and meridional radius is 2100 meters; grazing angle of incidence is 5.7 mradians; mirror may be lowered away from incident beam path; located 10.25 meters from the source.

b) **Monochromator**
Double flat crystal monochromator (Golovchenko type); piezoelectric driver with feedback keeps crystals in parallel alignment; crystal movement ranges from 7° - 68° Bragg angle; located 22.5 meters from the source.

- vertical and horizontal slits located before mirror and monochromator may be positioned in 3 μm steps.
- a set of six attenuators can be remotely inserted into the beam after the monochromator.

Experimental Apparatus

Radiation hutch and ion chambers.

Computer System Hardware and Software

PDP 11/24 computer; dual RL02 disk drive; LA-100 DECwriter; VT100 terminal; Selanar 100XL; HP printer/plotter; data phone.

May 4, 1987

Beam Line:	X11A
Ring:	X-Ray
Operational Status:	Operational

Participating Institutions: North Carolina State U., U. of Connecticut, BNL, U. of Washington, Mobil, Dupont, Argonne National Laboratory, Celanese, Notre Dame U., Georgia Tech. U., Lawrence Livermore Laboratory.

Local Contact: Steve Heald (516)282-5611, 2861; BNL

Spokesperson: Dale Sayers (919)737-3482; North Carolina State U.

Research Program: EXAFS

Energy Range (keV)	Crystal Type	Resolution ($\Delta E/E$)	Flux (photons/sec.)	Spot Size - unfocused (mm)	Total Horizontal Angular Acceptance (mradians)
3.5 - 22	Si(111)	2×10^{-4}	1×10^{10} @ 10 keV (100 mA, 2.5 GeV)	10H x 0.5V	0.5 - unfocused
11 - 40	Si(400)	2×10^{-4}	5×10^{8} @ 25 keV (100 mA, 2.5 GeV)	10H x 0.5V	0.5 - unfocused

Optical Configuration

a) **Mirror**
Rhodium coated spherical silicon carbide collimating mirror; 700 mm long by 100 mm wide; fixed position but may be lowered away from incident beam path; 20 keV cutoff; located 9 meters from the source; currently removed for recoating and repolishing, reinstallation date unknown.

b) **Monochromator**
Convertible from a two to a four flat crystal monochromator; presently operating in unfocused mode, focused mode to be introduced ~Spring 1988, thus collecting 5 mradians; located 12 meters from the source.

1) **Two-Crystal Mode**
Parameters given in the above Table.

2) **Four-Crystal Mode**
All above values remain essentially the same except the Energy Resolution for the Si(111) = 1.3 x 10^{-4} and for Si(400) = 2.3 x 10^{-5}, with some loss of intensity.

Experimental Apparatus

Radiation hutch; ion chambers for detecting I_0, I and fluorescence; slit and filter system for fluorescence detection; horizontal and vertical adjustable sample stand (~50 lbs. capacity); DISPLEX refrigerator @ 10° to 300°K; liquid N_2 dewer @ 80°K.

Computer System Hardware and Software

DEC 11/34 computer; RL02 disk storage; tape drive; Tektronix 4010 graphics terminal with hardcopy capability; data acquisition software allowing various types of scans including operation of user stepping motors; data analysis package for plotting and EXAFS analysis up through background subtraction; programs for aligning samples; link with BNL-VAX cluster.

May 19, 1987

Beam Line:	X11B
Ring:	X-Ray
Operational Status:	Construction Operational Summer 88

Participating Institutions: North Carolina State U., U. of Connecticut, BNL, U. of Washington, Mobil, Dupont, Argonne National Laboratory, Celanese, Notre Dame U., Georgia Tech. U., Lawrence Livermore Laboratory.

Local Contact: Steve Heald (516)282-5611, 2861; BNL

Spokesperson: Dale Sayers (919)737-3482; North Carolina State U.

Research Program: EXAFS

Expected Values					
Energy Range (keV)	Crystal Type	Resolution ($\Delta E/E$)	Flux (photons/sec.)	Spot Size - focused (mm)	Total Horizontal Angular Acceptance (mradians)
2 - 8	Si(111)	2×10^{-4}	1×10^{11} @ 4 keV (100 mA, 2.5 GeV)	2.0H x 2.0V	5.0 - focused
1.7 - 8	InSb(111)	2×10^{-4}	0.5×10^{11} @ 4 keV (100 mA, 2.5 GeV)	2.0H x 2.0V	5.0 - focused

Optical Configuration

a) **Monochromator**
Double flat crystal fixed exit monochromator operating at UHV; crystal carousels capable of holding four pairs of crystals which may be switched in UHV; first crystal of each pair is water-cooled; cover 8° - 70° Bragg angles; located 12 meters from the source.

b) **Mirror**
Toroidal aluminum mirror coated with platinum, used to focus beam at sample 24 meters from the source; collects 6 mradians; operates at a 10 mradian glancing angle; high energy cutoff is 8 keV; located 13 meters from the source.

Experimental Apparatus

Radiation hutch; ion chambers for detecting I_o, I and fluorescence; turbo-pumped soft x-ray chamber for rapid sample exchange.

Computer System Hardware and Software

DEC 11/34 computer; RL02 disk storage; tape drive; Tektronix 4010 graphics terminal with hardcopy capability; data acquisition software allowing various types of scans including operation of user stepping motors; data analysis package for plotting and EXAFS analysis up through background subtraction; programs for aligning samples; link with BNL-VAX cluster.

May 18, 1987

Beam Line:	X12B
Ring:	X-Ray
Operational Status:	Commissioning Operational Fall 87

Participating Institutions: BNL - Biology Department, NSLS

Local Contact: Malcom Capel (516)282-5712, 2792; BNL

Spokesperson: Malcolm Capel

Research Program: Small angle scattering

Expected Values					
Energy Range (keV)	Crystal Type	Resolution ($\Delta\lambda/\lambda$)	Flux (photons/sec.)	Spot Size - focused (mm)	Total Horizontal Angular Acceptance (mradians)
4 - 20	Si(111)	$<10^{-3}$		0.3H x 0.3V	3 (max.)

Optical Configuration

a) **Mirror No. 1**

1:1 rhodium coated silicon carbide doubly focusing toroidal mirror; 480 mm long by 10 mm wide; focusing point 7 meters from source; nominal incident angle is 3 mradians; position controlled by three stepping motors (mirror is presently being repolished and will be available in Winter 1987); located 3.5 meters from the source.

b) **Monochromator**

Double flat crystal monocromator; crystals are fixed in angle and position relative to input beam as wavelength is tuned; single stepping motor control of Bragg angle; operates in two angular ranges - 8° to 15° Bragg angle (short wavelength) and 13.5° to 70° Bragg angle (long wavelength) with a resolution of $<5 \times 10^{-5}$ degrees; located 14.7 meters from the source.

c) **Mirror No. 2**

1:1 rhodium coated electroless nickel plated aluminum cylinder bent to an approximate ellipsoid; 680 mm long by 30 mm wide; focal point 25 meters from source; nominal incident angle is 3 mradians; position controlled by three stepping motors; located 16 meters from the source.

Experimental Apparatus

Radiation hutch; spectrometer with detector arm cantilevered from an offset 2Θ axis; 3 circle goniometer; sample changer; stopped-flow cell; T-jump cell; stepping motor and position encoder for each spectrometer axis; high resolution/high rate linear detector; very high rate linear detector; position sensitive area detector; all detectors can be run in time-slicing mode; detectors do not have to be at position of focal point.

Computer System Hardware and Software

Hierarchical data acquisition system comprised of eight processors and peripheral equipment linked by a shared memory module - 1) LSI 11/23 experimental control processor, RSX11M operating system; 2) LSI 11/2 time-slicing processor and a LSI 11/2 display processor, RSX11M operating system; 3) LSI 11/73 data communications processor, RSX11M operating system and DECnet network software; 4) LSI 11/2 input/output processor, RSX11S operating system.

Reference

Wise, D.S. and B.P. Schoenborn. January 1985. Small Angle X-Ray Scattering Instrumentation for Structural Biology at the National Synchrotron Light Source; In: Polymer Research at Synchrotron Radiation Sources, Ed. by T.P. Russell and A.N. Goland, Brookhaven National Laboratory, Upton, NY, BNL Report 51847; pp. 11-20.

May 15, 1987

Beam Line:	X12C
Ring:	X-Ray
Operational Status:	Operational

Participating Institutions: BNL - Biology Department

Local Contact: Robert Sweet (516)282-5712, 5642, 3401; BNL

Spokesperson: Robert Sweet

Research Program: Protein crystallography

Energy Range (keV)	Crystal Type	Resolution ($\Delta E/E$)	Flux - mirror unbent ($photons/sec./mm^2$)	Spot Size - focused (mm)	Total Horizontal Angular Acceptance (mradians)
7 - 11	Si(111)	1×10^{-3} to 1×10^{-4}	4×10^{10} (meas.) @ 7 - 11 keV (80 mA, 2.5 GeV)	0.6H x 0.6V - may be slitted to smaller dimensions	2

Optical Configuration

a) **Monochromator**
A pair of single flat crystal monochromators; incidence angle adjustable about horizontal axis for first crystal; second crystal rotates in parallel to the first and has fixed exit geometry; stepping motor controls real-time adjustment of wavelength in 1 eV increments; Ge crystals will be available in the future; located 7.6 meters from the source.

b) **Mirror**
Aluminum electroless nickel-plated rhodium-coated cylindrical 1:1 focusing mirror; focal point at x-ray film 18 meters from source; glancing angle is 2 mradians; high energy cutoff is 25 keV; bending provides vertical focusing; located 9 meters from the source.

Experimental Apparatus

Radition hutch; Arndt/Wonacott rotation camera associated with beam monitor and stepping motor; flat (12.5 cm^2) film cassettes; able to collect data to a resolution approaching 1.6 Å or from specimens with unit cell dimensions of up to 600 Å; dark room; wet laboratory; air stream specimen cooler (ambient to -20 ° C).

Computer System Hardware and Software

PDP 11/23+ dedicated microcomputer for driving camera and associated apparatus.

June 12, 1987

Beam Line:	X14A
Ring:	X-Ray
Operational Status:	Operational

Participating Institutions: Oak Ridge National Laboratory - Oak Ridge Associated Universities

Local Contact: Gene E. Ice (516)282-5614; BNL

Spokesperson: Cullie J. Sparks, Jr. (615)574-6996; Oak Ridge National Laboratory

Research Program: Scattering, crystallography, spectroscopy

Energy Range (keV)	Crystal Type	Resolution ($\Delta E/E$)	Flux (photons/sec.)	Spot Size - focused (mm)	Total Horizontal Angular Acceptance (mradians)
2 - 40	Si(111)	2×10^{-4}	1×10^{13} @ 8 keV (500 mA, 2.5 GeV)	1.5H x 1.0V	15

Optical Configuration

a) **Mirror**
Platinum coated flat aluminum mirror of cantilever design; 700 mm long x 120 mm wide; variable vertical focusing or collimation; incident angles between 1 and 10 mradians; located 7.5 meters from the source.

b) **Monochromator**
Horizontally focusing double crystal monochromator; adjustable focal point from 13.3 - 30 meters from source; first crystal is water-cooled and flat; second crystal is conically bent; located 9.3 meters from the source.

Experimental Apparatus

Radiation hutch; four circle Huber diffractometer with crystal analyzer (Si, Ge, LiF, graphite crystals); SiLi solid state detector; Tracor-Northern multi-channel analyzer; sample chambers for polycrystalline and gaseous materials; diffuse scattering chamber from liquid N_2 to 300 °C; microprobe pinholes down to 0.5 μm diameter.

Computer System Hardware and Software

Data acquisition by a PDP 11/84 computer; RSX11M+ operating system; data analysis by a MicroVAX computer with VMS operating system; Tektronix 4010 compatible graphics terminals; CAMAC modules; PLOT 10 plotting package; SYNDAS crystallography program; various Θ - 2Θ scan routines.

May 13, 1987

Beam Line:	X15A
Ring:	X-Ray
Operational Status:	Operational

Participating Institutions: AT&T Bell Labs

Local Contact: Brian Kincaid (516)282-5615; BNL
(201)582-6673; AT&T Bell Labs

Spokesperson: Brian Kincaid

Research Program: X-ray standing wave, soft x-ray spectroscopy, x-ray lithography

Energy Range (keV)	Crystal Type	Resolution ($\Delta E/E$)	Flux (photons/sec.)	Spot Size - unfocused (mm)	Total Horizontal Angular Acceptance (mradians)
White Beam 3 - 20	White Beam Si(111)	White Beam 2×10^{-4}	White Beam 1×10^{11} @ 8 keV 500 mA, 2.5 GeV	200H x 2V 15H x 2V	15 1 - 2 - unfocused

Optical Configuration

Monochromator
Double parallel flat crystal monochromator located in hutch; air-bearing mechanism; manual removal of crystals necessary for white beam mode.

Experimental Apparatus

Radiation hutch suitable for white beam mode; "pocket" EXAFS; proposed upgrade - molecular beam epitaxy equipment for x-ray standing wave experiments.

Computer System Hardware and Software

Two AT&T PC6300's (IBM PC compatible - one supports beam line equipment and one supports experimental data acquisition); CAMAC crate with interface ; PC peripheral interface with printer; experimental control software in BASIC; BASIC, FORTRAN and C languages supported; Bell Labs EXAFS analysis package available.

May 11, 1987

Beam Line:	X15B
Ring:	X-Ray
Operational Status:	Commissioning Operational Fall 87

Participating Institutions: AT&T Bell Labs

Local Contact: Alastair MacDowell (516)282-3565; BNL

Spokesperson: Paul Citrin (201)582-5275; AT&T Bell Labs

Research Program: EXAFS, SEXAFS

Expected Values					
Energy Range (keV)	Crystal Type	Resolution @E_c ($\Delta E/E$)	Flux (photons/sec.)	Spot Size - focused (mm)	Total Horizontal Angular Acceptance (mradians)
0.7 - 12	Si(111)*	2×10^{-4}	2×10^{11} @ 5 keV (E_c) (100 mA, 2.5 GeV)	<1.0H x <1.0V	5

*Other crystals to be used include: beryl($10\bar{1}0$), InSb(111), Ge(111), Si(220)

Optical Configuration

a) **Mirror No. 1**
Cylindrical platinum coated aluminum mirror; mirror is cooled; mirror collimates beam onto first crystal of monochromator; incidence grazing angle (0.4° to 1.5° range) can be adjusted to discriminate against harmonics; located 8 meters from the source.

b) **Monochromator**
Double flat crytal UHV compatible monochromator with fixed exit geometry; first crystal is cooled; Bragg angle range from 10° to 80°; located 10 meters from the source.

c) **Mirror No. 2**
1:1 focusing platinum coated aluminum toroidal mirror for focusing beam onto sample 22 meters from source.

Experimental Apparatus

Ultra-high vacuum chamber operating independently of radiation hutch.

Computer System Hardware and Software

AT&T PC6300 computer with 30 MB disk and floppy; associated software and graphics.

May 11, 1987

Beam Line:	X16A
Ring:	X-Ray
Operational Status:	Operational

Participating Institutions: AT&T Bell Labs

Local Contact: Denis McWhan (516)282-5716, 3927; BNL (201)582-4557; AT&T Bell Labs

Spokesperson: Paul Fuoss (201)949-3581; AT&T Bell Labs

Research Program: Surface diffraction

Energy Range (keV)	Crystal Type	REsolution ($\Delta E/E$)	Flux (photons/sec.)	Spot Size - focused (mm)	Total Horizontal Angular Acceptance (mradians)
4 - 12	Si(111)	1×10^{-3}	6×10^{10} @ 8.4 keV (100 mA, 2.5 GeV)	2H x 0.5V	5

Optical Configuration

a) **Mirror**
1:1 platinum coated cylindrically cut bent focusing quartz mirror, focal point will be at sample in surface chamber located 25.8 meters from source; horizontal acceptance is 5 mradians; pre-mirror vertical slits and horizontal aperture adjust beam dimensions; mirror located 12.9 meters from the source.

b) **Monochromator**
Scanning constant offset double flat crystal monochromator (Golovchenko/ Cowan design); operates at 10^{-8} Torr; lock-in tuning system scannable over 300 eV range; range of incident angle is 7° - 60°; located 22 meters from the source.

Experimental Apparatus

Radiation hutch with adjustable optical table and incident beam flight path; the principle investigators have a UHV surface diffraction chamber and they should be contacted directly regarding its availability; the apparatus consists of a four circle Huber diffractometer integral with a sample preparation chamber (LEED/Auger, ion sputtering, residual gas analysis), vertical scattering geometry, chamber mounted on a motorized translation table to accomodate focused and unfocused conditions, entrance and exit slits define beam; analyzer section and scintillation detectors.

Computer System Hardware and Software

PDP 11/73 computer running UNIX operating system with SUPER software.

May 11, 1987.

Beam Line:	X16B
Ring:	X-Ray
Operational Status:	Operational

Participating Institutions: AT&T Bell Labs

Local Contact: Denis McWhan (516)282-5716, 3927; BNL (201)582-4557; AT&T Bell Labs

Spokesperson: Denis McWhan

Research Program: Diffraction

Energy Range (keV)	Crystal Type	Resolution ($\Delta E/E$)	Flux (photons/sec.)	Spot Size - focused (mm)	Total Horizontal Angular Acceptance (mradians)
7.85	Ge(111)	1×10^{-4}	2×10^{10} @ 7.85 keV (100 mA, 2.5 GeV)	0.5H x 5V	2

Optical Configuration

Monochromator

Horizontal fixed energy single bent asymmetric crystal monochromator; horizontal and vertical beam acceptance defined by adjustable slits located upstream; future upgrade - mirror for vertical focusing; monochromator located 22 meters from the source.

Experimental Apparatus

Radiation hutch; six circle Huber diffractometer in a vertical scattering configuration; entrance and exit slits define beam; scintillation detectors; crystal analyzer with polarization analysis; sample located 26 meters from the source.

Computer System Hardware and Software

PDP 11/73 computer using UNIX operating system with SUPER software and online plotting and fitting routines.

May 12, 1987

Beam Line:	X16C
Ring:	X-Ray
Operational Status:	Operational

Participating Institutions: AT&T Bell Labs

Local Contact: Denis McWhan (516)282-5716, 3927; BNL (201)582-4557; AT&T Bell Labs

Spokesperson: Denis McWhan

Research Program: Diffraction

Energy Range (keV)	Crystal Type	Resolution ($\Delta E/E$)	Flux (photons/sec.)	Spot Size - unfocused (mm)	Total Horizontal Angular Acceptance (mradians)
5 - 15	Si(111)	5×10^{-4}	10^{10} (meas.) @ 8 keV (50 mA, 2.5 GeV)	25H x 2V (hor. adjustable) to max. of 25 mm)	2.0 (max.)
White Beam	White Beam	White Beam	White Beam	25H x 2V	2.0 (max.)

Optical Configuration

a) **Monochromator**
Scanning constant-offset double flat crystal monochromator (Golovchenko /Cowan design); operates at 10^{-8} Torr; ~100 eV tuning range (dynamic) limited by the range of the piezo, can be centered around any energy from 5 - 15 keV; range of incident angle is 7° - 60°; located within radiation hutch at 15.9 meters from the source.

b) **Crystals**
Removable for white beam mode.

Experimental Apparatus

Radiation hutch suitable for white beam mode; two circle #410 Huber diffractometer in a vertical scattering plane; motorized goniometer for alignment; scintillation monitor and detector; crystal analyzer.

Computer System Hardware and Software

AT&T PC6300 computer running UNIX operating system with SUPER software.

May 12, 1987

Beam Line:	X17B1
Ring:	X-Ray
Operational Status:	Construction Operational by 88

Insertion Device Team: NSLS, California State U. at Fullerton, Argonne National Laboratory, SUNY at Buffalo, Brookhaven National Laboratory, Stanford U., Carnegie Institute of Washington, Lawrence Berkeley Laboratory, National Bureau of Standards

Local Contact: Dean Chapman (516)282-4744; BNL

Spokesperson: William Thomlinson (516)282-3937; BNL

Research Program: Materials sciences - chemical crystallography, EXAFS, high pressure physics, topography, x-ray scattering

Expected Values					
Energy Range (keV)	Source	Crystal Type	Resolution ($\Delta E/E$)	Flux (phot./sec./mrad/ 1% bw/0.5A)	Total Horizontal Angular Acceptance (mradians)
4 - 100 ($E_c = 20$)	Superconducting Wiggler - 5 poles @ 5T - 2 poles @2.5T - 17.4 cm period	Si: low index reflections	2×10^{-4}	10^{15} @ 20 keV (500 mA, 2.5 GeV) - source output after filters	0 - 5 - variable - unfocused
White Beam		White Beam	White Beam	White Beam	0 - 5

Optical Configuration

a) **Monochromator**
Two crystal non-dispersive monochromator; located 23 meters from the wiggler source.

b) **Filters**
Front end contains 0.391 mm of graphite filters (18) and 0.508 mm of beryllium filters (2); a gas filter is also available.

Experimental Apparatus

Radiation hutch; six circle Huber diffractometer with kinematic mount; sample located 30 meters from the wiggler source; hutch can accomodate a wide range of additional experimental hardware.

Computer System Hardware and Software

MicroVAXII computer, VAX/VMS operating system; two graphics terminals; DMA CAMAC crate controller with CAMAC crate, stepper motor control via CAMAC; two 71 MB Winchester drives; dual 5 1/4" floppy disk drives; one 95 MB streamer tape; Ethernet link.

May 5, 1987

Beam Line:	X17B2
Ring:	X-Ray
Operational Status:	Construction Operational by 88

Insertion Device Team: NSLS, Stanford U., Lawrence Berkeley Laboratory, Stanford Synchrotron Radiation Laboratory, BNL - Medical Department

Local Contact: William Thomlinson (516)282-3937; BNL

Spokesperson: William Thomlinson

Research Program: Medical research - angiography, radiotherapy

Expected Values					
Energy Range (keV)	Source	Crystal Type	Resolution ($\Delta E/E$)	Flux (phot./sec./mrad/ 1% bw/0.5A)	Total Horizontal Angular Acceptance (mradians)
32 - 36 (Fixed Energies)	Superconducting Wiggler - 5 poles @ 5T - 2 poles @ 2.5T 17.4 cm period	Si: low index reflections	5×10^{-4}	8×10^{14} @ 33 keV (500 mA, 2.5 GeV) - output after C and Be filters 4×10^{14} - output after C, Be, Xe filters	variable from 0 - 5 - horizontal is unfocused - vertical is focused or apertured to 0.5 mm

Optical Configuration

a) **Monochromator**
Fixed dual energy monochromator, energies set to bracket the iodine K-edge at 33.169 keV; located 34 meters from the wiggler source.

b) **Filters**
Front end contains 0.391 mm of graphite filters (18) and 0.508 mm of beryllium filters (2); a xenon gas filter is also available.

Experimental Apparatus

Large radiation hutch associated with a clinical facility positioned downstream of and operating alternately with X17B1 (patient position for angiography experiments located 37 meters from wiggler source); 600 element silicon detector with 0.25 mm spatial resolution being developed for dual energy angiography imaging.

Computer System Hardware and Software

To be determined by angiography program requirements.

May 6, 1987

Beam Line:	X17C
Ring:	X-Ray
Operational Status:	Construction Operational by 88

Insertion Device Team: Lawrence Livermore National Laboratory, U. of Washington, U. of California - Berkeley, Exxon, State U. of New York - Stony Brook, U. of Hawaii, Carnegie Institute of Washington, AT&T Bell Labs, Cornell U., Los Alamos National Laboratory, Naval Research Laboratory

Local Contact: Denis McWhan (516)282-3927; BNL

Spokesperson: Earl Skelton (202)767-3014; Naval Research Laboratory

Research Program: High pressure research

Expected Values					
Energy Range (keV)	Source	Crystal Type	Resolution ($\Delta E/E$)	Flux (phot./sec./mrad/ 1% bw/0.5A)	Total Horizontal Angular Acceptance (mradians)
White Beam 4 - 100 ($E_c = 20$)	Superconducting Wiggler - 5 poles @ 5T - 2 poles @ 2.5T - 17.4 cm period	White Beam	White Beam	White Beam 10^{15} @ 20 keV (500 mA, 2.5 GeV) - source output after filters	0 - 2 - variable - unfocused

OpticalConfiguration

a) **White Beam**
Entrance port is located approximately 25 meters from the wiggler source.

b) **Filters**
Front end contains 0.391 mm of graphite filters (18) and 0.508 mm of beryllium filters (2); a gas filter is also available.

Experimental Apparatus

Radiation hutch; computer controlled sample/cell and detector tables located $\sim$ 26 meters from the wiggler source; solid state detectors and associated electronics.

Computer System Hardware and Software

To be determined.

May 21, 1987

Beam Line:	X18A
Ring:	X-Ray
Operational Status:	Operational

Participating Institutions: MATRIX - a consortium of midwestern universities - Purdue U., Northwestern U., U. of Illinois, U. of Missouri, Iowa State U., Argonne National Laboratory.

Local Contact: Steven Ehrlich (516)282-5618, 7862; BNL

Spokesperson: Gerry Liedl (317)494-4095; Purdue University

Research Program: Diffuse and surface scattering

Energy Range (keV)	Crystal Type	Resolution ($\Delta E/E$)	Flux (photons/sec.)	Spot Size - focused (mm)	Total Horizontal Angular Acceptance (mradians)
4 - 20	Si(111)	5×10^{-4}	$\sim 10^{10} - 10^{11}$ @ 10 keV (50 mA, 2.5 GeV)	1.5H x 1.0V	0 - 6

Optical Configuration

a) **Monochromator**
Double flat crystal monochromator; first crystal is water-cooled; typical crystal movement from 6° to 29° Bragg angle; located 10 meters from the source.

b) **Mirror**
Cylindrical rhodium coated aluminum 1:1 focusing mirror and mirror bender (in construction); high energy cutoff is 12 keV; located 12 meters from the source.

Experimental Apparatus

Radiation hutch; four circle Huber diffractometer with crystal analyzer (various crystal types available); scintillation detectors; ionization chambers; Si(Li) detector; CTI low temperature stage (10 - 300K) with gas inlet to sample chamber; UHV surface diffraction chamber mountable on Huber - low temperature chamber capability under development; time-resolving counting system with minimum time resolution starting at 20 nsec. with up to 8K time bins.

Computer System Hardware and Software

PDP 11/34 computer; RSX11M operating system; Tektronix 4010 compatible graphics terminal; CAMAC modules; RL02 and RX02 disk storage; nine track magnetic tape; LeCroy 3500M multi-channel analyzer with modules; GPIB capability on LeCroy and 11/34; data acquisition and analysis software.

May 20, 1987

Beam Line:	X18B
Ring:	X-Ray
Operational Status:	Operational

Participating Institutions: West Virginia U., Brooklyn College of CUNY, U. of Pittsburgh, Chevron, Allied Signal Engineered Materials Research Center, GTE.

Local Contact: Mohan Ramanathan (516)282-5718; BNL
(304)293-3498; West Virginia U.

Spokesperson: Pedro Montano (718)859-5779; Brooklyn College of CUNY
(304)293-3422; West Virginia U.

Research Program: EXAFS

Energy Range (keV)	Crystal Type	Resolution ($\Delta E/E$)	Flux (photons/sec.)	Maximum Spot Size - unfocused (mm)	Total Horizontal Angular Acceptance (mradians)
2.4 - 16	Si(111)			22.0H x 5.0V	1.0
6 - 26	Si(220)			22.0H x 5.0V	1.0

Optical Configuration

Monochromator

Double flat crystal monochromator with fixed entry and exit; UHV compatible; first crystal is water-cooled; crystal dimensions are 5 cm x 5 cm x 1 cm thick; crystals are easily interchangeable; typical crystal movement from 7° to 68° Bragg angle; located 20 meters from the source.

Experimental Apparatus

Radiation hutch; ion chambers; fluorescence detectors; multi-channel analyzer.

Computer System Hardware and Software

PDP 11/24 computer; RSX-11M+ operating system; CAMAC interface; RL02 disk drives and nine-track magnetic tape drive; VT125 and Tektronix emulating graphics terminals; graphics compatible printer; complete data acquisition and EXAFS analysis software package.

June 5, 1987

Beam Line:	X19A
Ring:	X-Ray
Operational Status:	Commissioning Operational Summer 88

Participating Institutions: NSLS

Local Contact: Peter Stefan (516)282-5619, 2117; BNL

Spokesperson: Peter Stefan

Research Program: X-ray spectroscopy, EXAFS

Expected Values					
Energy Range (keV)	Crystal Type	Resolution ($\Delta E/E$)	Flux (photons/sec.)	Spot Size (mm)	Total Horizontal Angular Acceptance (mradians)
2.1 - 8.2 3.4 - 13.8	Si(111) Si(220)	2×10^{-4} 5×10^{-5}	$\sim 10^{11}$ @ 5 keV (100 mA, 2.5 GeV)	40H x 5V unfocused $\sim$1 mm diam focused	3
7.6 - 13.4 12.5 - 23.0	Si(111) Si(220)	2×10^{-4} 5×10^{-5}	$\sim 5 \times 10^{11}$ @ 11 keV (100 mA, 2.5GeV)	40H x 5V unfocused $\sim$1 mm diam focused	3

Optical Configuration

a) **Mirror No. 1**
Silicon carbide rhodium coated spherical collimating mirror, to eliminate inherent vertical divergence of incident beam; high energy cutoff is 23 keV; incidence angle is 3 mradians; located 8 meters from the source (to be installed late 1988).

b) **Monochromator**
NSLS boomerang-type double flat crystal monochromator; fixed exit geometry; first crystal is water-cooled; operates at UHV; two presettable Bragg angle ranges of 13.5° - 70° and 8.5° - 15°; located 9.3 meters from the source.

c) **Mirror No. 2**
Cylindrical aluminum focusing mirror, electroless nickel plated and overcoated with rhodium, for focusing beam onto sample at 18.5 meters from the source; 3 mradian incidence angle; 23 keV high energy cutoff; mirror may be dropped out of beam path for unfocused mode; located 10.5 meters from the source.

NB. Beam line is UHV up to window located inside radiation hutch.

Experimental Apparatus

Positioning table using stepper motor controls, two perpendicular translations and effectively three mutually perpendicular rotations.

Computer System Hardware and Software

MicroVAXII computer with CAMAC interface running Micro-VMS operating system.

May 6, 1987

Beam Line:	X19C
Ring:	X-Ray
Operational Status:	Operational

Participating Institutions: NSLS, Synchrotron Topography Project - California State College at Fullerton, Johns Hopkins U., SUNY at Stony Brook, U. of Illinois at Urbana, U. of Pennsylvania

Local Contact: Anthony Hmelo (516)282-5719; BNL
(516)632-8500; SUNY at Stony Brook

Spokesperson: Michael Dudley (516)632-8500; SUNY at Stony Brook

Research Program: Topography

Energy Range (keV)	Crystal Type	Resolution ($\Delta E/E$)	Flux (photons/sec./ mrad/0.1% bw/ 100 mA)	Beam Size Available (mm)	Total Horizontal Angular Acceptance (mradians)
4 - 25	White Beam	White Beam	4.16×10^{12} (meas.) @ 4.9 keV (100 mA, 2.5 GeV)	40.0H x 7.0V	2
4 - 20	Si(111)	$\sim 10^{-3}$		40.0H x 7.0V	2

Optical Configuration

a) **White Beam Mode**
Slit-defined white beam radiation; capability of introducing various absorbers into beam path to modify incident spectral distribution.

b) **Monochromator Mode**
Constant offset double flat crystal (Golovchenko type) monochromator; first crystal is water-cooled; operates in the atmosphere; operates in tandem with multiple crystal topography camera downstream of monochromator; easily positioned in and out of beam path; located inside radiation hutch 21 meters from the source.

Experimental Apparatus

Radiation hutch; five circle Huber goniometer with computer controlled robotic detector arm for positioning x-ray detectors; multiple crystal topography camera configured on two separately kinematically mounted platforms, the first a two meter long granite bench supporting a combination of Huber goniometer stages and the second supporting other goniometer stages manipulating the specimen - operate in tandem with the monochromator to produce a planar collimated monochromatic x-ray beam; environmental chamber with beryllium exit and entrance windows, chamber mounts in eulerian cradle of white beam camera, remote manipulators, furnace, mechanical tensile stage; scintillation detectors; real-time x-ray television with two-inch square aperture; dark-room for development of x-ray films.

Computer System Hardware and Software

PDP 11/23 computer; RSX-11M+ operating system; NSL motor control unit to adjust various system stepping motors; application software.

July 17, 1987

Beam Line:	X20A
Ring:	X-Ray
Operational Status:	Operational

Participating Institutions: IBM, Massachusetts Institute of Technology

Local Contact: Jean Jordan-Sweet (516)282-5720; BNL

Spokesperson: Paul Horn (914)945-2445; IBM T.J. Watson Research Center

Research Program: Scattering, EXAFS

Energy Range (keV)	Crystal Type	Resolution ($\Delta E/E$)	Flux (photons/sec.)	Spot Size - focused (mm)	Total Horizontal Angular Acceptance (mradians)
3 - 13	Si(111)	2×10^{-4}	2×10^{11} @ 9 keV (100 mA, 2.5 GeV)	1.0H x 1.0V	4
3 - 13	Ge(111)	4×10^{-4}	4×10^{11} @ 9 keV (100 mA, 2.5 GeV)	1.0H x 1.0V	4

Optical Configuration

a) **Mirror**

Platinum coated silicon, adjustably bent cylinder mirror with 1:1 focusing to focus beam onto sample located 25 meters from the source; mirror length is 600 mm; high energy cutoff is 13 keV; mirror located 12.8 meters from the source.

b) **Monochromator**

Scanning double crystal fixed exit beam monochromator; first crystal is water cooled; PZT servo on second crystal; Bragg angle ranges from 8° to 90° 2Θ; located 16 meters from the source.

Experimental Apparatus

Radiation hutch with 12' ceiling; six circle Huber diffractometer operating with ion chamber and scintillation detector as beam monitors and uses scintillation detector for signal detection; computer controlled table for Huber.

Computer System Hardware and Software

IBM PC operates CAMAC interface; on-line graphics and software for four circle operation.

May 29, 1987

Beam Line:	X20B
Ring:	X-Ray
Operational Status:	Construction Operational Summer 88

Participating Institutions: IBM, Massachusetts Institute of Technology

Local Contact: Jean Jordan-Sweet (516)282-5720; BNL

Spokesperson: Paul Horn (914)945-2445; IBM T.J. Watson Research Center

Research Program: Scattering at fixed energy

Expected Values					
Energy Range (keV)	Crystal Type	Resolution ($\Delta E/E$)	Flux (photons/sec.)	Spot Size - focused (mm)	Total Horizontal Angular Acceptance (mradians)
16.8	Si(111)	1×10^{-3} (theor.)	5×10^{10} (theor.) @ 16.8 keV (100 mA, 2.5 GeV)	0.5H x 11V	1

Optical Configuration

Monochromator

Horizontally bent silicon crystal monochromator located 19.6 meters from the source and 13.4 meters from the sample.

Experimental Apparatus

Radiation hutch with 12' ceiling; six circle Huber diffractometer operating with ion chamber and scintillation detector as beam monitors and uses scintillation detector for signal detection; computer controlled table for Huber.

Computer System Hardware and Software

IBM PC operates CAMAC interface; on-line graphics and software for four circle operation.

May 29, 1987

Beam Line:	X20C
Ring:	X-Ray
Operational Status:	Operational

Participating Institutions: IBM, Massachusetts Institute of Technology

Local Contact: Jean Jordan-Sweet (516)282-5720; BNL

Spokesperson: Paul Horn (914)945-2445; IBM T.J. Watson Research Center

Research Program: Scattering (variable Q resolution), EXAFS

Energy Range (keV)	Crystal Type	Resolution ($\Delta E/E$)	Flux (photons/sec.)	Spot Size - focused (mm)	Total Horizontal Angular Acceptance (mradians)
3 - 11	Si(111)	2×10^{-4}	2×10^{11} @ 9 keV (100 mA, 2.5 GeV)	1.0H x 1.0V	4
3 - 11	Ge(111)	4×10^{-4}	4×10^{11} @ 9 keV (100 mA, 2.5 GeV)	1.0H x 1.0V	4
3 - 8	23 Å d-spacing multi-layer	1.2×10^{-2}	1×10^{13} @ 6 keV (100 mA, 2.5 GeV)	1.0H x 1.0V	4

Optical Configuration

a) **Mirror**
Platinum coated silicon, adjustably bent cylinder mirror with 1:1 focusing to focus beam onto sample located 22 meters from source; mirror length is 600 mm; high energy cutoff is 11 keV; mirror located 10.8 meters from the source.

b) **Monochromator**
Scanning double crystal fixed exit beam monochromator; first crystal is water cooled; PZT servo on second crystal; Bragg angle ranges from 4° to 90° 2Θ; located 14 meters from the source.

Experimental Apparatus

Radiation hutch with 12' ceiling; six circle Huber diffractometer operating with ion chamber and scintillation detector as beam monitors and uses scintillation detector for signal detection; computer controlled table for Huber; data collection with a diode-array linear detector, 0.05 mm/channel, 500 channels.

Computer System Hardware and Software

IBM PC operates CAMAC interface; on-line graphics and software for four circle operation.

May 29, 1987

Beam Line:	X21
Ring:	X-Ray
Operational Status:	Conceptual Operational by 89

Insertion Device Team: NSLS, Exxon

Local Contact: Jerome Hastings (516)282-3930; BNL

Spokesperson: Jerome Hastings

Research Program: High energy resolution inelastic scattering

Expected Values					
Energy Range (keV)	Source	Crystal Type	Resolution ($\Delta E/E$)	Flux (photons/sec.)	Total Horizontal Angular Acceptance (mradians)
$E > 4$ same as bending magnet	Hybrid wiggler - 15 periods - 12 cm period	Special purpose backscattering crystals	$\sim 3 \times 10^{-6}$		~ 3

Optical Configuration

The conceptual design for this beam line directs the beam to a hutch located 30 meters from the wiggler source. The beam is offset vertically by one meter by a two crystal monochromator. The beam is then directed to a second hutch located 60 meters from the wiggler source where it is reflected and focused by a spherically bent silicon crystal back to the upstream hutch and the experimental station. The scattered beam from the sample will be energy analyzed by an appropriately designed crystal instrument.

Experimental Apparatus

Not as yet defined.

Computer System Hardware and Software

Not as yet defined.

June 8, 1987

Beam Line:	X22B
Ring:	X-Ray
Operational Status:	Operational

Participating Institutions: BNL - Physics Department, Harvard U. - Division of Applied Sciences

Local Contact: John Axe (516)282-5622, 3821; BNL

Spokesperson: John Axe

Research Program: High resolution x-ray diffraction

Energy Range (keV)	Crystal Type	Resolution ($\Delta E/E$)	Flux (phot./sec.)	Spot Size - unfocused (mm)	Total Horizontal Angular Acceptance (mradians)
Fixed at 7.3	Ge(111)	$\geq 3 \times 10^{-4}$	2×10^{11} (calc.) @ 7 keV (500 mA, 2.5 GeV)	40.0H x 4.0V	1

Optical Configuration

Monochromator

Single flat crystal monochromator; 2Θ fixed at 14°; adjustable horizontal and vertical slits before monochromator; monochromator vacuum isolated from beam line by beryllium windows; located 18 meters from the source (modifications to provide vertical focusing and variable monochromator 2Θ are presently underway).

Experimental Apparatus

Three circle Huber spectrometer with horizontal scattering geometry, located 20 meters from the source; eulerian cradle; $2\Theta_S$ from -10° to 130°; crystal analyzer with Ge(111) crystals; photomultiplier detector; instrument can be converted into reflectometer for grazing angle specular reflection.

Computer System Hardware and Software

PDP 11/73 computer; VENIX operating system; hard disk; data acquisition through CAMAC interface.

June 5, 1987

Beam Line:	X22C
Ring:	X-Ray
Operational Status:	Operational

Participating Institutions: BNL - Physics Department

Local Contact: Doon Gibbs (516)282-5622, 4608; BNL

Spokesperson: John Axe (516)282-3821; BNL

Research Program: Diffraction studies of magnetic and structural phase transformations, surface scattering

Energy Range (keV)	Crystal Type	Resolution ($\Delta E/E$)	Flux (photons/sec.)	Spot Size - focused (mm)	Total Horizontal Angular Acceptance (mradians)
3 - 30	Ge(111)	3×10^{-4}	6×10^{11} @ 7 keV (500 mA, 2.5 GeV)	0.4H x 0.4V	6

Optical Configuration

a) **Mirror**
Bent cylindrical nickel coated aluminum focusing mirror for 1:1 focusing at sample; mirror is in vacuum and separated from ring by a beryllium window; located 10 meters from the source.

b) **Monochromator**
Double monochromator, $7^\circ < 2\Theta_M < 70^\circ$ in vertical plane; in vacuum and isolated from mirror tank by a beryllium window; located 15 meters from the source.

- adjustable vertical and horizontal slits are located upstream of hutch.

Experimental Apparatus

Radiation hutch; Franke and Heydrich four circle spectrometer with vertical scattering geometry; $2\Theta_S$ from -50° to $+140^\circ$; Ge(111) crystal analyzer; photomultiplier detector; UHV surface scattering chamber.

Computer System Hardware and Software

PDP 11/73 computer using VENIX operating system, hard disk and data acquisition through CAMAC interface.

June 8, 1987

Beam Line:	X23A2
Ring:	X-Ray
Operational Status:	Commissioning Operational Fall 87

Participating Institutions: National Bureau of Standards

Local Contact: Richard Spal (516)282-5623, 2279; BNL

Spokesperson: Masao Kuriyama (301)975-5974; National Bureau of Standards

Research Program: EXAFS, SEXAFS with standing wave and photoelectron detection, specular x-ray reflection

Expected Values					
Energy Range (keV)	Crystal Type	Resolution ($\Delta E/E$)	Flux (photons/sec.)	Spot Size - focused (mm)	Total Horizontal Angular Acceptance (mradians)
5 - 30	Si(220)	2×10^{-4}	5×10^{8} - at monochromator bandpass @ 10 keV (100 mA, 2.5 GeV)	25H x 1.0V	4

Optical Configuration

a) **Monochromator**
Upwards reflecting, fixed exit Golovchenko-Cowan design; piezo-feedback stabilized with auto-detuning to reject harmonics.

b) **Mirror**
None at present.

Experimental Apparatus

Radiation hutch; ion chambers for beam intensity monitor, transmitted intensity and harmonic monitor; silicon photodiodes for fluorescence detection; sample translation stage with 2 inch vertical and horizontal travel, supports 10 kg; adjustable horizontal and vertical exit slits; alignment stage for glancing angle work. As this is a side station, experimental apparatus must be designed consistent with a pass-through pipe 2 inches below and 1 inch to the side of the A2 beam edge.

Computer System Hardware and Software

DEC 11/73 computer; 85 MB hard disk; Selanar HiRez 100 terminal for text and graphics; printer; data acquisition software for EXAFS, user control of stepper motors and plotting; analysis software; link to tape drive on X23B through DECnet; access to ARPAnet.

May 21, 1987

Beam Line:	X23A3
Ring:	X-Ray
Operational Status:	Operational

Participating Institutions: National Bureau of Standards

Local Contact: Richard Spal (516)282-5623, 2279; BNL

Spokesperson: Masao Kuriyama (301)975-5974; National Bureau of Standards

Research Program: Real time topography, microradiography, energy dispersive diffractometry, white beam experiments, EXAFS

Energy Range (keV)	Crystal Type	Resolution ($\Delta E/E$)	Flux (phot./sec./0.1% bw/ mrad)	Spot Size - unfocused (mm)	Total Horizontal Angular Acceptance (mradians)
White Beam 5 - 20	White Beam Si(111)*	White Beam 1.25×10^{-4} @ 8 keV	White Beam 10^{11} @ 8 keV (100 mA, 2.5 GeV)	40H x 4V Variable to 35H x 35V with H & V slitting	2 2

*other diffracting planes available without changing crystals; other crystals available covering a range of asymmetry factors.

Optical Configuration

Monochromator

Double flat crystal nonfocusing nondispersive monochromator; beam allowed to pass through for white beam experiments; provides a vertically diffracted, high flux beam to sample 25 cm above white beam at 20 meters from the source; fixed exit geometry for monochromatic beam; independently controlled rotation and translation stages for each crystal; coarse adjustment of Bragg angle by stepper motor rotation stage (0.5 arc-sec/step), fine adjustment by piezoelectric tilt stage; two position-sensitive ion chambers monitor beam flux and position at entrance and exit slit; fully automatic alignment and energy selection; monochromator located 17 meters from the source. A second two crystal dispersive monochromator with almost the same characteristics as above may be used in tandem with the above monochromator to provide a vertically and horizontally diffracted, highly collimated beam; located inside the A3 hutch.

Experimental Apparatus

Radiation hutch; sample stage rotates horizontally and vertically, also translates horizontally and vertically with 2.5 μm resolution, translates vertically by 25 cm to shift sample between white and monochromatic beams, can support a 20 kg environmental chamber; detector stage rotates about single axis and translates along three orthogonal axes; x-ray image magnifier (up to 100x) may be mounted on detector stage; film and x-ray video cameras (to 25 μm spatial resolution) are available as image detectors.

Computer System Hardware and Software

LSI 11/23 microcomputer; RT11 operating system; CAMAC interface and stepper motor controllers; RL01 removable cartridge disk drive; RX02 floppy disk drive; graphics video monitor; dot matrix printer; frame grabber for image detector.

May 22, 1987

Beam Line:	X23B
Ring:	X-Ray
Operational Status:	Operational

Participating Institutions: Naval Research Laboratory

Local Contact: John Kirkland (516)282-5723; BNL
Richard Neiser (516)282-5723; BNL

Spokesperson: W.T. Elam (202)767-3014; Naval Research Laboratory

Research Program: Scattering, crystallography, EXAFS

Energy Range (keV)	Crystal Type	Resolution ($\Delta E/E$)	Flux (photons/sec./mA)	Spot Size (mm)	Total Horizontal Angular Acceptance (mradians)
3 - 11	Si(111)	4×10^{-4} @ 6.5 keV (measured)	2.3×10^{9} @ 6 keV, 2.5 GeV (measured)	1.0H x 3.0V (measured)	6

Optical Configuration

a) **Mirror No. 1**
Platinum coated flat copper collimating mirror; 400 mm long by 70 mm wide; collimation achieved by four point bending; high energy cutoff is 10 keV; angle of incidence is 7.15 mradians; located 7.9 meters from the source.

b) **Monochromator**
Fixed exit position double crystal monochromator (Cowan type); two ranges of incident angle are 8° - 15° and 13.5° - 70°; located 9.2 meters from the source.

c) **Mirror No. 2**
Platinum coated quartz toroidal mirror; 580 mm long by 70 mm wide and sagittal radius of 84 mm; vertical focusing achieved by four point bending; focal point at 23.5 meters from the source; angle of incidence is 7.15 mradians; high energy cutoff is 10 keV; located 11.75 meters from the source.

Experimental Apparatus

Radiation hutch; four circle Huber diffractometer with crystal analyzer.

Computer System Hardware and Software

PDP 11/73 computer; RSX-11M+ operating system; Tektronix 4014 compatible graphics terminals; PLOT 10 plotting package; HP plotter; IBM PC/AT computer.

July 15, 1987

Beam Line:	X24A
Ring:	X-Ray
Operational Status:	Operational

Participating Institutions: National Bureau of Standards - Quantum Metrology Group

Local Contact: Barry Karlin (516)282-5624; BNL
Paul Cowan (301)975-4846; National Bureau of Standards

Spokesperson: Richard Deslattes (301)975-4841; National Bureau of Standards

Research Program: X-ray spectroscopy, atomic and molecular physics

Energy Range (keV)	Crystal Type	Resolving Power ($\Delta E/E$)	Flux (photons/sec. @ 100 mA, 2.5 GeV)	Spot Size - focused (mm)	Total Horizontal Angular Acceptance (mradians)
2.1 - 5	Si(111)	7000 - 8000	7-20 x 10^{11} (calc.)	0.8H x 2.5V	9.5
1.55 - 5	Quartz ($10\bar{1}0$)	8600 - 13,500	1-40 x 10^{10} (calc.)	0.8H x 2.5V	9.5
0.85 - 2.3	Beryl ($10\bar{1}0$)	2500 - 4000	1-40 x 10^{9} (calc.)	0.8H x 2.5V	9.5

Optical Configuration

a) **Mirror No. 1**
Nickel coated aluminum spherical collimating mirror; 300 mm long by 80 mm wide, radius is 1000 meters; variable incidence angle (0 - 50 mradians); removable from beam path; located 6.8 meters from the source.

b) **Monochromator**
Ultra-high vacuum, constant offset double flat crystal monochromator (boomerang linkage type); feedback stabilized; 14° - 70° Bragg angle range; located 7.7 meters from the source.

c) **Mirror No. 2**
Nickel coated quartz toroidal focusing mirror; 580 mm long by 88 mm wide, sagittal radius is 100 mm, meridional radius is 800 meters; incident angle is 10.65 mradians; high energy cutoff is 5 keV; 1:1 focusing at 18.4 meters from the source; located 9.2 meters from the source.

Experimental Apparatus

Ultra-high vacuum chamber; atmospheric gas sample cells; ultra-high vacuum manipulator; double-pass CMA electron spectrometer; high energy resolution, Rowland circle, curved crystal x-ray spectrometer.

Computer System Hardware and Software

PDP 11/23 computer with VT240 graphics terminal and 30 MB fixed hard disk and two RX02 eight inch floppies; RT-11 operating system; CAMAC interface for data acquisition and beam line motion control; PDP 11/2 computer for vacuum monitoring control.

May 29, 1987

Beam Line:	X24C
Ring:	X-Ray
Operational Status:	Operational

Participating Institutions: Naval Research Laboratory

Local Contact: Jack Rife (516)282-5624; BNL
(202)767-4654; Naval Research Laboratory

Spokesperson: Milton Kabler (202)767-2223; Naval Research Laboratory

Research Program: Photoemission and reflectance spectroscopy

Energy Range (eV)	Grating or Crystal Type	Resolution ($\Delta E/E$)	Flux (photons/sec. @ 0.1% $\Delta\lambda/\lambda$) (100 mA, 2.5 GeV)	Spot Size - focused (mm)	Total Angular Acceptance (mradians)
2 - 120	600 grooves/mm	10^{-3}	10^{11}	0.8H x 0.7V	6H x 1V
120 - 800	2400 grooves/mm	10^{-3}	10^{11}	0.8H x 0.7V	6H x 1V
800 - 1800	Beryl crystal	10^{-3}	$>10^{10}$	0.8H x 0.7V	6H x 1V

Optical Configuration

a) **Mirror No. 1**
Platinum coated, fixed curvature paraboloidal mirror (M1); beam collimated into monochromator; 2° grazing angle; full orientation control; located 10 meters from the source.

b) **Monochromator**
Grating/crystal monochromator; double crystal type scanning motion; uses either gratings or crystals in vacuum with exchange; 600 grooves/mm grating has a 2° blaze and is silicon coated; 2400 grooves/mm grating has a 2° blaze and is gold coated; 3° to 87° grazing angle range; located 13.5 meters from the source.

c) **Mirror No. 2**
Platinum coated, fixed curvature paraboloidal mirror (M2) identical to M1; beam focused onto exit slit 26 meters from the source yielding 1:1 image of source; 2° grazing angle; full orientation control; located 16 meters from the source.

Exmerimental Apparatus

Two interchangable 18" diameter UHV bell jars; reflectometer with sample adjustable in angle of incidence and orientation around sample normal; photodiode or channeltron detectors capable of being set at a fixed distance but any angle about sample; whole chamber can be rotated to alter polarization; surface science chamber with double pass cylindrical mirror analyzer; both chambers to be served by UHV sample preparation chamber.

Computer System Hardware and Software

LSI 11/73 computer with Tektronix 4025 graphics terminal and hardcopy; removable hard disk; data acquisition through CAMAC modules.

May 22, 1987

Beam Line:	X25
Ring:	X-Ray
Operational Status:	Construction Operational by 88

Insertion Device Team: NSLS, AT&T Bell Labs, IBM, Harvard U., BNL - Physics Department, Exxon

Local Contact: Lonny Berman (516)282-5625; BNL

Spokesperson: Jerome Hastings (516)282-3930; BNL

Research Program: High-Q resolution elastic scattering

Expected Values					
Energy Range (keV)	Source	Crystal Type	Resolution ($\Delta Q/Q$)	Flux (phot./sec./0.001% bw)	Total Horizontal Angular Acceptance (mradians)
E > 4 same as bending magnet	Hybrid wiggler - 15 periods - 12 cm period	Silicon: - low index reflections	$\sim 2 \times 10^{-4}$	6×10^{14} @ 10 keV (500 mA, 2.5 GeV) - source output integrated over vertical, 3 mrad horizontal	3 ($1.2\ K/\gamma$ at $B_o = 1.1$ T

Optical Configuration

a) **Condensing Mirror**
Typically 1:1 focusing; located 15 meters from the undulator source.

b) **Monochromator**
Two crystal non-dispersive monochromator.

Experimental Apparatus

Radiation hutch; six circle Huber diffractometer and a kinematic mount.

Copmputer System Hardware and Software

Not as yet defined.

May 8, 1987

Beam Line:	X26A,C
Ring:	X-Ray
Operational Status:	C is Operational A is planned and will be Operational in 88

Participating Institutions: BNL (DAS) - Division of Atomic and Applied Physics; DOE - Division of Chemical Sciences, National Institutes of Health Biotechnology Resource (national user facility); The University of Chicago National Science Foundation Geochemistry Project; Cornell U., Texas A&M, U. of Tennessee.

Local Contact: Keith Jones (516)282-5626, 5726, 4588; BNL

Spokesperson: Keith Jones

Research Program: Development and application of analytical techniques (e.g. microprobe) in chemistry, geochemistry, biology, medicine and other fields, atomic physics processes and applications in photoexcitation, photoionization, multiply charged atoms. Beam lines A and C used as appropriate.

Expected Values			
Energy Range (keV)	Beam Line	Spot Size	Total Horizontal Angular Acceptance (mradians)
4 - 20	A - Microprobe	30 μm^2 to 8 mmH x 1.6 mmV	~0.5
White Beam	C - White Beam	Apertured to 0.01 - 5 mm in horizontal and vertical	5

Optical Configuration

A-Line

a) **Monochromator**
Double flat crystal monochromator with fixed exit geometry; located 6 meters from the source.

b) **Mirror**
8:1 ellipsoidal aluminum focusing mirror coated with platinum, focal point at sample 9 meters from source; high energy cutoff is 18 keV; located 8 meters from the source.

C-Line

Installation of 1:1 cylindrical focusing mirror, located 10 meters from the source; windowless operation scheduled for 1988.

Experimental Apparatus

A-Line

Radiation hutch; energy and wavelength dispersive spectrometers; xyz Θ sample position stages; remote microscopy.

C-Line

Radiation hutch; UV spectrometer; x-ray spectrometer; SiLi detectors; UHV vacuum system; ion trap; xyz Θ sample position stages.

Computer System Hardware and Software

LeCroy 3500 MCA; MicroVax II using VAX/VMS operating system; GANDALF link to BNL/AMD VAX cluster; hardcopy; data acquisition and analysis software.

May 12, 1987