1.1 Background

This *Progress Report* summarizes the activities of the APS Experimental Facilities Division (XFD) over the period 1997-98. The XFD personnel focused on supporting the Advanced Photon Source (APS) users from day-to-day operations support to long-term research and development (R&D) needs. The XFD personnel would like to proudly share their major accomplishments with the readers of this report.

Over the past eighteen months, many new beamlines have begun performing scientific research, and the user presence at the APS has grown continually. At Argonne National Laboratory (ANL), the APS has become the centerpiece of user programs, and many programmatic divisions at Argonne have started to derive the benefit of this major research resource.

Thirty-five of the forty storage ring sectors include both insertion device and bending magnet sources. Of these 35 sectors, the Accelerator Systems Division (ASD) uses radiation from one undulator (35-ID) and one bending magnet source (35-BM) to perform storage ring diagnostics. The remaining 34 sectors are for the R&D work by the APS users.

In the first phase of the APS (Phase-1), 20 of these 34 sectors have been instrumented behind the shield wall to deliver insertion device and bending magnet radiation to the APS users. As of August 1998, the users have built beamlines in 19 of the 20 sectors as planned, and XFD personnel have installed and commissioned insertion devices and beamline front ends to provide radiation to all the APS user beamlines. In addition, Personnel Safety Systems (PSS) have been designed to meet user needs. These PSS have been installed, validated, commissioned, and operated in over 80 experiment stations on these beamlines by XFD personnel in time to meet users' objectives. The majority of these beamlines have taken advantage of the 'standard and modular' beamline components designed, constructed, and tested by XFD.

The continued R&D support, advice, and guidance provided to the APS Collaborative Access Teams (CATs) by the XFD personnel has contributed to realizing early research at the majority of user beamlines. The Synchrotron Radiation Instrumentation (SRI) CAT, made up primarily of XFD personnel, has continued to make a major impact on the development of new instruments and techniques, as well as on new areas of science, using beamlines in three sectors (1, 2, and 3). The 'Scientific Members' of SRI-CAT have participated extensively with the XFD staff in performing frontier scientific research.

SRI-CAT has begun construction of a beamline in sector 4 that will be dedicated to the development of instruments and techniques to explore the frontiers of science using polarized x-rays. In addition, XFD is now getting ready for newer CATs planning to build beamlines in sectors beyond 21.

This report summarizes many of the primary activities and accomplishments of the XFD personnel in supporting APS users.

1.2 Mission of the APS Experimental Facilities Division

The mission of the XFD is unchanged and is consistent with the vision of the APS to function as a reliable and preeminent source of synchrotron radiation for APS users.

XFD believes that we can best serve the APS user community by investing in three important goals: reliable and successful operation, high-quality user technical and administrative support, and innovative R&D in support of user operations and scientific research. These goals enable us to go beyond the traditional role of Department of Energy (DOE) user facilities to create an intelligent partnership with our users.

We commit ourselves to an organization that shares the following principles:

- Understanding our users' operational goals and striving to exceed their needs
- Providing seamless support to our users in all areas
- Creating a rewarding, enriching, and collaborative R&D environment for our staff and the users to facilitate the long-term success of the APS as the premier user facility in the world
- Expanding our worldwide leadership role in the synchrotron radiation community
- Assuring the safety of APS users, visitors, and APS/XFD personnel, and the protection of the environment
- Approaching our daily work with enthusiasm, a dedication to users and a sense of humor

1.3 APS User Sector Layout

In Figure 1.1, the most current layout of the APS experiment hall floor and allocation of sectors to various CATs is shown. Each sector consists of two sources for beamlines. In all, 18 sectors have undulators, one sector (BioCARS) has a wiggler, and the last (BESSRC) has an elliptical multipole wiggler for the production of circularly polarized radiation. Except for the newly formed UNI-CAT-2 (sector 34), the beamlines constructed in all other sectors have received radiation. The two new sectors recently assigned are sector 4 to SRI-CAT and sector 32 to COM-CAT, in which beamline construction is now beginning. The major scientific disciplines of each of the sectors are identified in Figure 1.1. They are (a) condensed matter physics, chemical science, and materials science, (b) health science (biology), (c) environmental science, geoscience, soil science, and agricultural science, and (d) synchrotron radiation instrumentation and techniques. It is in this last area that XFD has a major commitment.

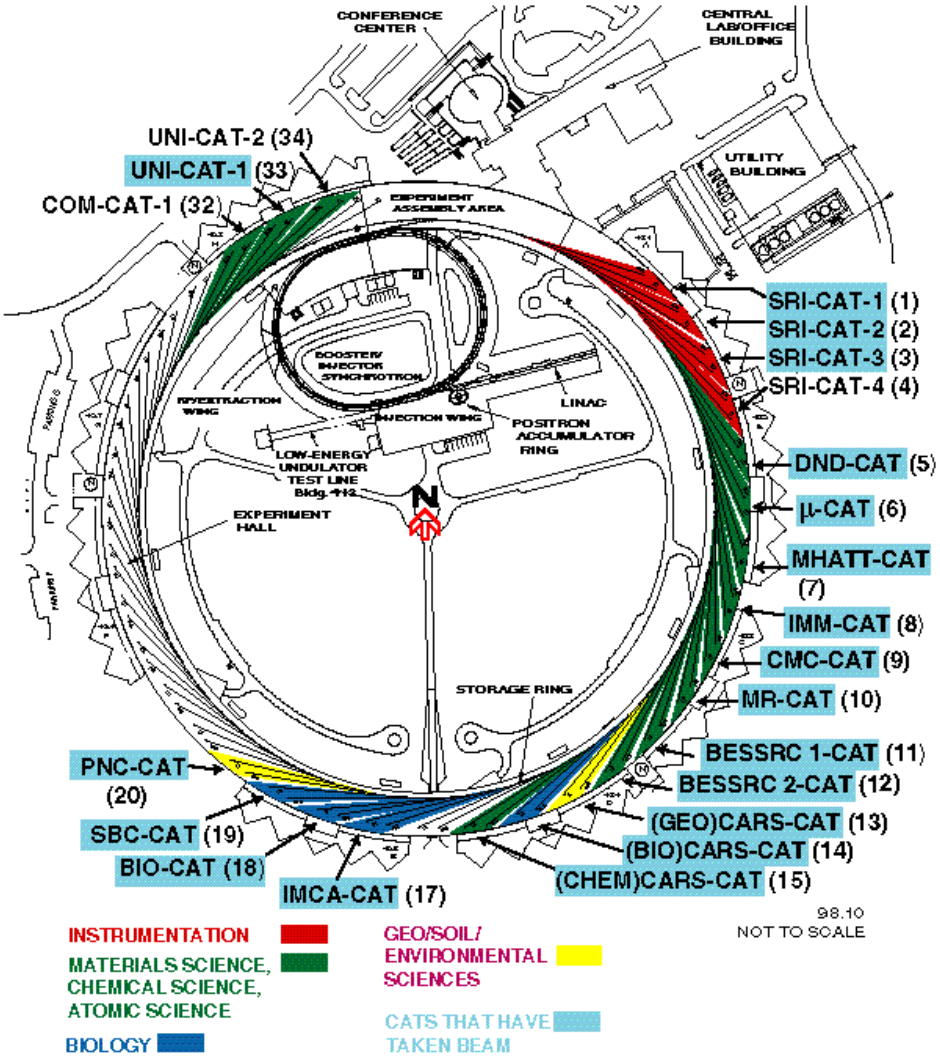

Fig. 1.1 APS Collaborative Access Teams by sector and discipline.

1.4 XFD Organization

The XFD organization has three functional areas as shown in Fig 1.2. The XFD organization structure, shown in Fig 1.3, defines various groups by specialization. This structure folds into functional organization and guarantees excellent communication and interaction across the boundaries of the groups to meet both the groups' and XFD's objectives.

1.5 User Operations

This functional unit supports user operations at the APS and consists of the Beamline Operations Group, the Safety Interlocks and Instrumentation Group, and, recently, the

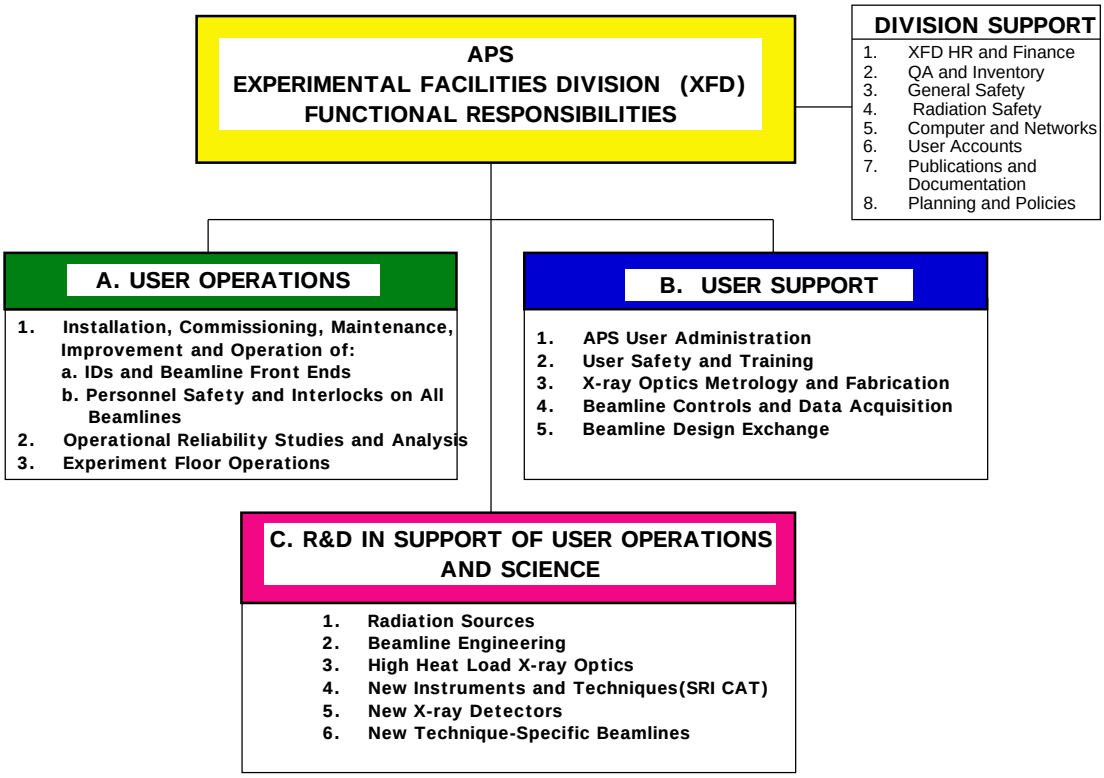

Fig. 1.2 XFD is organized into three functional areas: (A) User Operations, (B) User Support, and (C) R&D in Support of User Operations and Science.

Experiment Floor Operations Group. The groups use the expertise of the XFD radiation physicist and a project engineer in all user beamline design, procurement, and commissioning activities. During the past 18 months, these groups have performed installation, commissioning, and routine maintenance of all insertion devices, beamline front ends, experiment enclosures, PSS, and Equipment Protection Systems (EPS), in addition to reliability studies and analysis leading to design changes and upgrades of components. Their main objective is to assure the highest level of reliability of operations of the radiation sources, beamline components, and PSS. There has been less than 0.7% of downtime in user beam time over a 12 month period (April 97 - March 1998) associated with XFD operations. This has supported the highest level of productivity from the APS users. Continued operational improvements are planned to decrease the downtime even further.

The number of experiment stations has nearly tripled during the past 18 months. The XFD support to the CATs on these experiment enclosures starts with their design, management of procurement contracts, installation supervision (both technical and safety) of the contractor workers, installation of the PSS, commissioning, shielding verification (and revalidation) using Argonne health physics technicians, and finally operations. At the present time over 80 experiment stations are operational at the APS.

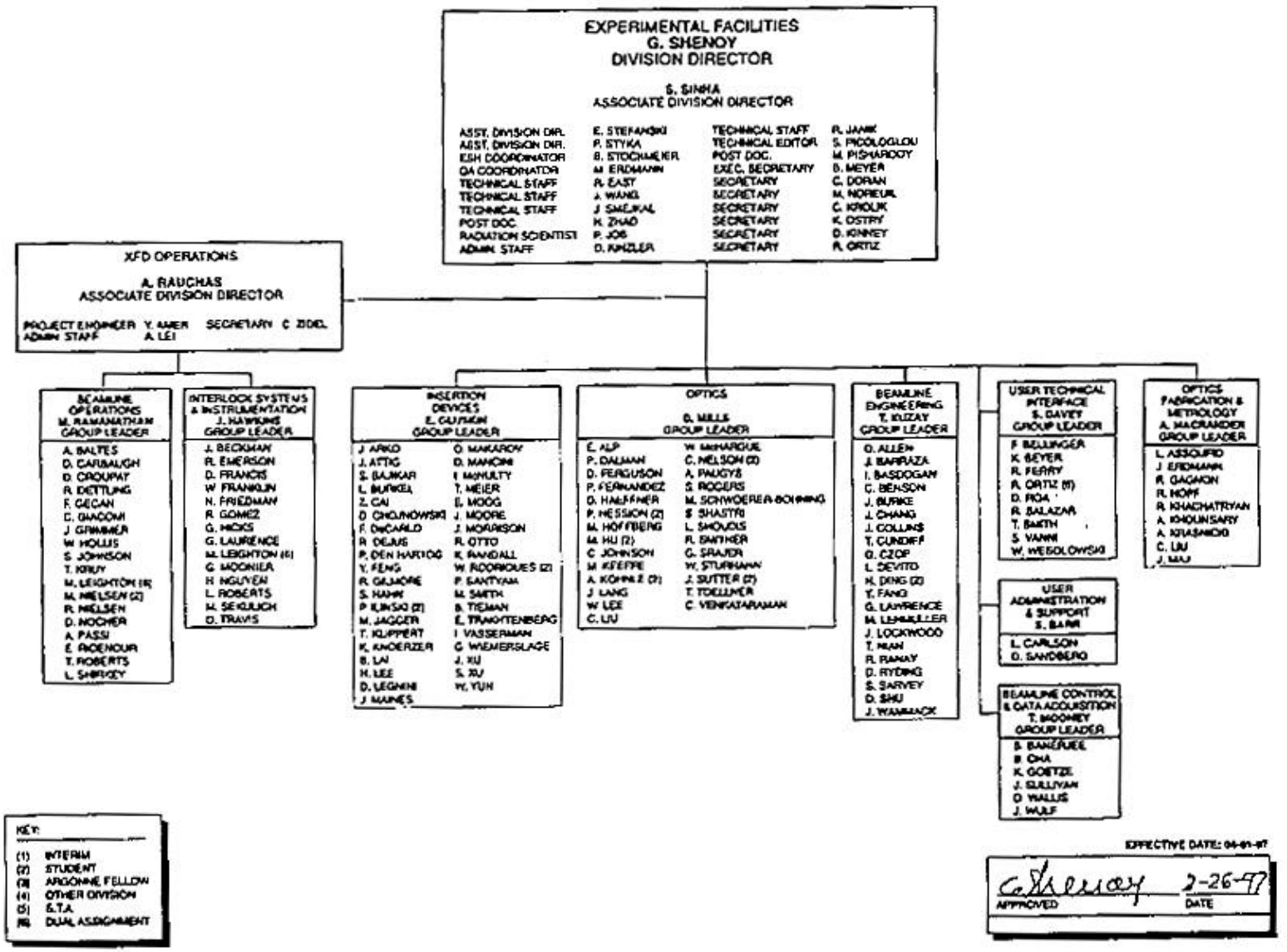

Fig. 1.3 Experimental Facilities Division organization chart

In terms of reorganization, the Floor Operations Group consisting of floor coordinators was formed during this year and reports to the Associate Division Director for XFD Operations. The Floor Operations Group meets day-to-day user needs, provides oversight on user safety, and maintains the authority to suspend any of the user activities if it is felt that unsafe conditions may exist. The floor coordinators are the first point of contact on all topics of interest to the APS users on the experiment hall floor.

1.6 APS User Administration and Technical Support

This activity is supported by many groups: User Administration and Support, User Technical Interface, X-ray Optics Metrology and Fabrication, Beamline Controls and Data Acquisition, and the staff involved in the operation of the Design Exchange. These groups continue to provide support to the APS users in all areas in a seamless fashion. Some of their principal activities include:

- Technical support in the design of instruments, beamlines and experiments
- Administrative support, user orientation, safety training, etc.
- Development of user policies and procedures
- Development and maintenance of user databases to support user needs, user access to the APS, user demographics, safety training records, experiment safety approval records, publication records, scientific program review records, independent investigator proposal activities, etc.
- Beamline controls and data acquisition support to most of the APS CATs, and support of the capability for remote operation of experiments at the APS beamlines from user home institutions
- Design and fabrication of a variety of crystal, mirror, and multilayer optics for APS CAT beamlines and evaluation of their performance
- Management of cost accounts for over 100 APS user institutions with dollar amounts ranging from a few thousand to many millions including the costs of stock-room items as well as major beamline components

1.7 R&D in Support of User Operations and Scientific Research

R&D in support of user operations is an important function primarily provided by the Insertion Device Group, Beamline Engineering Group, and X-ray Optics Group. These groups support the XFD Operations Groups in meeting their objectives by providing expert guidance and redesign assistance as needed. This arrangement has worked well during the past year.

A second responsibility is to perform R&D to address unique issues for the present and the future needs of the users, such as

superior beam stability, mechanical and optical components for 300-mA operation, support of user experiments during 'top-up' mode, special operating modes to meet the needs of all users, and unique radiation sources and beamline requirements.

A third functional responsibility is to provide the highest quality leadership in synchrotron radiation instrumentation and technique development in order to support and enhance the APS users' scientific research. Many of these activities, having both short- and long-term scientific benefit to the user community, are performed through SRI-CAT.

The accomplishments of these groups over the past 18 months have been extensive as measured from the quality and number of publications and invited presentations. (See Appendix 1 for publications and Appendix 2 for invited presentations.)

1.8 SRI-CAT

New directions in science result from scientific revolution. In the past, scientific revolutions—big or small, global or local—have been driven by either new concepts or new tools. The staff involved in SRI-CAT firmly believe that tool-driven revolution adds much to the progress of science. In his book *Imagined Worlds*, the author Freeman Dyson[1] points out that the effect of a concept-driven revolution is to explain old things in new ways. The effect of a tool-driven revolution is to discover new things that have to be explained. During the past year, SRI-CAT has been involved in a host of tool-driven discoveries in synchrotron-based science. Examples include microprobe tools leading to quantitative studies in agricultural and environmental sciences, understanding of diagnostics and treatment of cancer, the role of residual stress in relationship to failure in materials, and the ability to measure element-specific dynamics of atoms in complex fluids; high-energy-resolution tools leading to the science of phonons in thin films and amorphous systems; x-ray polarization tools leading to tomographic images of magnetic domains and understanding of magnetic surface roughness so very important in modern data storage technologies; deep x-ray lithography, which would lead to the development of new microscopic tools for physical measurements; high-energy x-ray scattering to probe glasses and liquids; soft and hard x-ray tomographic imaging tools to explore their application to modern technology, such as integrated circuits, and to ancient artifacts, such as dinosaur teeth; refining the broad spectrum of absorption and scattering tools to open the new field of x-ray archaeometallurgy; inelastic and Raman x-ray scattering tools to understand collective phonon and electron behavior of unique condensed systems; coherence-based tools in the soft and hard x-ray energies to provide the new capability to study fluctuations in condensed matter; and the list goes on.

These tool-driven activities will remain the main focus of SRI-CAT for years to come and will complement the traditional responsibility of supporting the user community by providing basic resources in

[1] Freeman Dyson, *Imagined Worlds*, Harvard University Press, Cambridge, Massachusetts, 1997.

the development of new optics, beamline components, new techniques, etc.

The accomplishments and future plans of SRI-CAT are discussed in more detail elsewhere in this document. (See Appendix 3 for a list of current SRI-CAT members.)

1.9 Collaborative Work

During the past year the major collaborative activities of the XFD staff have been:

- Design and construction of all undulator vacuum chambers for the new BESSY II storage ring in Berlin
- Design and construction of the vacuum chamber for the free-electron laser (FEL) project TESLA at HASYLAB
- Performance evaluation of the TESLA FEL undulator system
- Construction of critical high-heat-load components for the SPring-8 undulator beamline front ends
- Design support to the beamline group at the synchrotron radiation facility in Taiwan
- Design and delivery of an 8-mm-aperture undulator vacuum chamber to the European Synchrotron Radiation Facility (ESRF)
- Beamline design support to COM-CAT, and assistance in managing State of Illinois funds for the beamlines
- Tuning of an undulator to meet unique technical specifications for the operation of a 5-micron self-amplified spontaneous emission (SASE) FEL at Brookhaven National Laboratory (BNL)

This work is in addition to innumerable hours of technical support and advice provided to all APS users and the CATs. These efforts point to the high regard of the world-wide synchrotron radiation community for work performed by XFD staff.

1.10 Long-Term R&D Plans

The staff in XFD actively participates in long-term R&D activities. These activities are supported by Laboratory Directed Research and Development (LDRD) funds distributed by the Argonne National Laboratory Director through a laboratory-wide competitive process. These funds are provided for the following four categories of initiatives:

1. Strategic Initiatives of the Laboratory (SI)
2. Research Initiatives of the APS (APS-RES)
3. Programs approved by the Coordination Council for Science and Technology to encourage interactions between various Argonne Divisions (CCST)

4. Individual Investigator program to promote unique ideas from individuals (IIP)

The following is a list of LDRD programs from the XFD staff funded during FY 1998:

1. Development of a long undulator line for a new generation of synchrotron radiation sources (SI)

2. Radiation damage to Nd-Fe-B permanent magnets due to very high radiation doses (SI)

3. Investigation of a SASE process in a 5-micron FEL (SI)

4. Development of x-ray intensity fluctuation spectroscopy (XIFS) for study of atomic-scale equilibrium dynamics (SI with the Materials Science Division - MSD)

5. Anomalous inelastic x-ray scattering with meV resolution (SI)

6. Chemical vapor deposition (CVD) diamond imaging detector (SI)

7. Nanometer-resolution x-ray zone plates (SI)

8. High-speed shutter for temporal modification of the APS x-ray beam (SI)

9. Development of micromachining technique based on deep x-ray lithography (DXRL) (APS-RES)

10. Low work function coatings and LIGA-type fabrication (CCST with MSD)

11. Short-focal-length crystal lens for use in medical imaging (IIP)

12. Compact laser Doppler linear encoder with near-angstrom resolution (IIP)