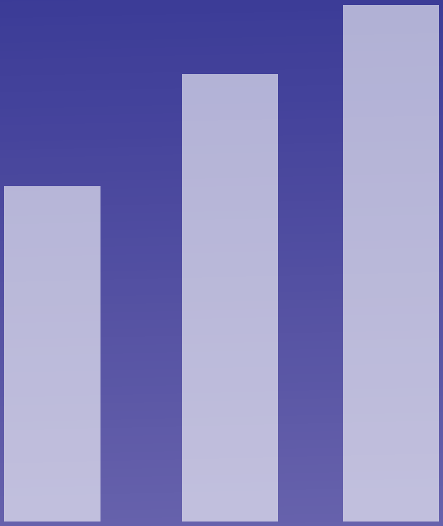
Access To Major International X-Ray and Neutron Scattering Facilities



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ACCESS TO MAJOR INTERNATIONAL X-RAY AND NEUTRON FACILITIES

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TABLE OF CONTENTS

List of Appendices:

1) **“Proposed Report” Statement from CISA to APS Board in November 2005**
(“Goals & Scope” document)

2) **List of Current Major Synchrotron X-ray & Neutron Facilities**

3) **List of Future Major Synchrotron X-ray & Neutron Facilities**

4) **Copy of Questionnaire to Synchrotron X-ray & Neutron Facilities**

5) **Copy of Questionnaire to Synchrotron X-ray & Neutron User Groups & Societies**

6) **List of Facilities, User Groups, and Societies that Responded to Questionnaires**

7) **Meetings Held**

8) **Previous Reports on Access**

9) **List of Acronyms**

ACCESS TO MAJOR INTERNATIONAL X-RAY AND NEUTRON SCATTERING FACILITIES

EXECUTIVE SUMMARY

The goal of this study is to explore how access to major international X-ray and neutron scattering facilities is evolving both in the US and internationally. A major facility is defined here as one that attracts users from at least across a nation, has an operating budget of $ 15 m or more and invites proposals for beamtime. Access means the opportunity to conduct an experiment at a major facility with assistance from the facility as needed to be successful.

To gather information we sent questionnaires to major facilities and to user groups and societies that support the fields of X-ray and neutron scattering worldwide. We also held discussions with many individuals both in the US and abroad. The conclusions of the study are presented in Section 7. In this Executive Summary we emphasize the factors setting and limiting access particularly as they affect US scientists.

Mechanisms of Access

A history of means of access to major X-ray and neutron facilities is presented in chapter 2. Today, access is chiefly via a written proposal to the facility to conduct an experiment. All of the 32 facilities responding to the study questionnaire have proposal programs and 60 -100 % of beamtime is allocated via proposals, depending on the facility. In all but two cases, all proposals, irrespective of origin, are reviewed for scientific merit by the same committees of peers. This mechanism and its variations globally are discussed in section 6.1. The user community is generally happy with the proposal access mechanism and it is expected to remain the chief mechanism. No facilities charge user fees.

Participating Research Teams (PRTs) (also denoted Collaborative Access Teams (CATs)) remain a productive access route, although somewhat out of favor at present in the USA. PRTs and CATs can both expand the number of beamlines/instruments at facilities and provide flexible access outside proposal program for Team members. They are well received where the PRT instruments are constructed and operated within strict facility criteria. For example at ESRF, where they are viewed as a success, PRTs (denoted CRGs in Europe) must demonstrate that the CRG beamline is unique and does not duplicate an existing beamline, will be constructed to conform to facility guidelines and will have adequate operating support. Although the number of PRTs in the US is dropping, typically 20 % of beamlines/instruments at European facilities are PRTs.

Foreign nationals have also been able to obtain funds in their countries to construct PRTs at US facilities. We could find no examples of US funded PRTs at foreign facilities.

- While the proposal system is expected to remain the major mechanism for access, establishing a funding mechanism in the USA for PRTs or CATs would greatly improve and expand this flexible component of access.

Experiments are done by research teams. Usually only a segment of the team goes to the facility to conduct an experiment. An increase in “Cyber Access” to the facility that would enable other team members to participate remotely would be an enormous step forward. Similarly access in which samples only are sent to facilities is increasing.

- Improvements in “Cyber Access” to instruments that would allow members of a research team not at the site to participate in the experiment remotely would be a major advance in access.

Visa restrictions remain a barrier in the USA. This barrier extends from the difficulty in admitting foreign graduate students and post doctoral associates into the country, to access for visa students at US facilities, to travel of visa students and associates abroad to conduct experiments. Some foreign scientists simply choose not to collaborate in the USA because of the difficulties inherent in the visa system. While we do not have a solution, visas and visa related security remain a barrier to access.

Access Mechanisms to Facilities abroad

Facilities abroad offer access and a means of expanding the research resources available to US researchers. Particularly, contact with and use of the best facilities in Europe and those emerging in Japan and China has proven rewarding for many US scientists.

The US policy on access to foreign facilities is an informal nation-to-nation policy: “we use your facilities and you use ours”. This generally operates well between national facilities. All US facilities are national facilities.

Europe and Russia, however, have both national and multinational facilities. At a multinational facility, several nations have come together to construct the facility and subsequently to provide the annual operating budget within a formal agreement. Specific examples are ILL and ESRF. When there is such a formal agreement, access is monitored by the supporting nations and each anticipates scientific access in approximate proportion to their support. In this environment, it is difficult for multinational facility to offer open access to scientists from nations that are not part of the consortium. In the case of the USA, there is a mismatch between the informal US policy “We use your facilities and you use ours” and the formal agreements at multinational facilities. This mismatch is discussed in section 6.1. The mismatch of the US informal policy and multinational facilities has been noted in other fields of science and is not unique to X-ray and neutron facilities (cf NSB Report 90-172 (1990) and OECD Megascience Forum Reports (1998)). Negotiations to transcend this difference would enhance international cooperation.

Use of all foreign facilities, national or multinational, is always possible through collaboration with scientists from the nations supporting the foreign facilities (see section 6.3).

- Increased international collaboration involving neutron and synchrotron facilities in the U.S. and abroad would bring major benefits to U.S. researchers as well as increase the impact of all facilities.

Instrument scientists

As the user community continues to expand, it will naturally include many scientists who are less familiar with performing experiments using neutrons and synchrotron X-rays. The evolution of the community is discussed in section 6.5.3. In addition, the rate at which data are collected during experiments continues to increase. In this environment, users will depend increasingly on facility instrument scientists for (1) scientifically insightful planning of experiments, (2) distinguishing important discovery from spurious instrument effects (3) data reduction and (4) data analysis so that their "access" leads to a scientifically successful outcome (see section 6.5.3 and 6.6). Instrument scientists have always been the key contacts for users. The fraction of users who can conduct experiments largely independently and who require little assistance is expected to decrease. Specifically,

- Scientifically successful access today, especially for new users, depends on the active assistance and collaboration of facility instrument scientists at a scientific level. This requires an increased number of instrument scientists and ensuring that they can remain scientifically active. This depends on (1) the education and training of fresh instrument scientists within the universities (2) the creation of attractive job opportunities, good promotion prospects and a satisfying career path for instrument scientists within the facilities and (3) ensuring that they have time and resources to develop and maintain their own scientific program.

Support for investigators

Support for individual investigators or groups of scientists, their post doctoral associates and graduate students in universities who use X-ray or neutron facilities is essential in maintaining a vital user community. It is also these individuals or groups who train future instrument scientists. In the US, this support comes in the form of individual/group research grants or contracts that are used to pay associates and students and to conduct experiments. The support for individual investigator programs as a fraction of total support in agencies such as NSF continues to decrease. We believe that this trend will a have deleterious long-term effect on the stability and health of the user community in the US and must be reversed.

- To create and ensure a world class and vital user community, support for the research programs of individual users in universities must remain strong and in reasonable balance with support for major facilities and other research centers.

At most European facilities (e.g. ISIS, Diamond, LLB, ESRF, ILL, DESY) user travel and accommodation expenses incurred in conducting experiments are paid through the facility. European scientists and facility direction find this practice important in supporting a user base.

Availability of facilities

Availability of facilities, particularly of X-ray beamlines and neutron scattering instruments on which experiments can be carried out, is central to access. The number of scientists seeking access to facilities in the US is increasing and when the success rate of proposals falls below roughly 30 %, scientists tend to move toward other research (see section 4.3)

The number of users and the number of accepted proposals for experiments at facilities is proportional to the number of instruments/beamlines and the time they are available. This is a central finding of the report (section 4.5). While raw beam intensity is important, it is also vital that facilities are fully instrumented with regular upgrades to all instruments. In addition to building new facilities such as LCLS and NSLSII, the user community can be enlarged by optimizing existing major facilities with beamlines, instruments and sample environment equipment. This represents a cost efficient way of expanding access for users. This finding agrees with that in the NRC Report, CMMP 2010, for both neutron and X-ray facilities.

- The number of users and the number of experiments conducted at a facility scales with the number of instruments (neutrons) or beamilines (X-rays) at the facility. The scientific access is maximized when all beam capacity is fully exploited and all beamlines are fully instrumented with modern instruments and associated sample environment equipment. The size of the US user community is currently limited by the number of instruments and beamlines.

- To enable world class, cutting edge science, it is important that beamlines, guide halls and instruments are regularly upgraded in a continuous program of facility instrument modernization.

In addition, availability can be further limited by the number of days that beamlines/instruments can be operated in the user program and by the number of instrument scientists available to assist users. Instruments and beamlines that have not been recently upgraded are often symptoms of an inadequate operating budget.

The NRC Report, CMMP 2010, recommends that a national plan for constructing and supporting Synchrotron X-ray facilities be developed by the supporting agencies (DOE, NSF, NIH) through Interagency Cooperation. This report supports this recommendation and finds support for including neutron facilities in this planning. Specifically,

- Further planning for the support and upgrade of existing X-Ray and neutron facilities and the construction of new facilities would be most effective if it includes Interagency Cooperation. This planning could also be placed an international context, keeping a watching brief on developments abroad so that opportunities for international cooperation in facility use, upgrade or construction can be realized.

Features of outstanding facilities and international perspective

Investigators in universities who use synchrotron X-rays and neutrons operate in a highly competitive environment for research funds. One of their major concerns is to demonstrate research achievement within the 3-year period of a single grant. In this context, investigators favor facilities that: (1) are reliable, (2) have unique instruments, (3) have excellent sample environment facilities and (4) have competent technical personnel and laboratory support staff, in that order (see Section 5.2). Other factors are rated as less important.

The world’s most productive neutron and X-ray users facilities (such as the NCNR and the APS in the U.S. and the ILL and the ESRF in Europe) have achieved their level of performance (usually after an extended start-up phase) by offering a wide range and a large number of modern beamlines and instruments, many of which are unique, combined with reliable operation and excellent, and again often unique, sample environment facilities.

There is a significant addition of world-class facilities in progress in the East: in Japan, in China and in Australia. This represents an important shift in major facilities.

SECTION 1: GOALS AND PURPOSE OF THE STUDY

1.1. Introduction and Goals

The national laboratories supported by the U.S. Department of Energy (DOE) and NIST supported by the Department of Commerce play a broad spectrum of vital roles in the nation. One key role of these laboratories is to build and operate major national research facilities, facilities that are too large and complex for a corporation or university to support and operate effectively. Today, these major facilities include X-ray synchrotron and neutron scattering facilities, as well as facilities for particle, nuclear and plasma physics. By building and operating these major facilities, the national laboratories play a unique and critical role in an interconnected national research enterprise made up of the corporations, universities and national laboratories. In order for this research enterprise to operate in an effective and integrated way, scientists from all sectors must have access to these facilities. This report reviews and analyzes the terms and conditions of access to major X-ray synchrotron and neutron scattering facilities. The ultimate goal of this report is to improve access for all, thereby fostering corporate-university-national laboratory collaboration in research.

Scientists and engineers in the US may also wish to use facilities at national laboratories abroad, for a variety of reasons. Facilities abroad may have unique or highly specialized instruments, have unique research programs in place or simply have facilities that are less heavily in use than those in the US. Similarly, scientists from abroad may wish to use US facilities. An additional goal of this study is therefore to investigate the availability and terms of access of facilities throughout the world, in Asia, Europe and in the US. This report is, therefore, international in scope. While the report naturally has a US perspective, we hope that the findings will be useful to users and facilities outside the United States.

This report is written from the perspective of the user of facilities. While this perspective may not fully recognize and acknowledge the constraints under which facilities and national laboratories operate, we hope that the perspective of the user will nonetheless, contribute useful information. Similarly, in the discussion of international facilities we may not fully recognize or understand the constraints under which facilities and users operate abroad.

Several previous studies have examined the scientific need for major facilities while making an overall assessment of a particular scientific field. An example is the 2007 National Research Council Report, “CMMP 2010: An Assessment of and Outlook for Condensed Matter and Materials Physics.” Other studies have focused exclusively on the US, assessing the status of major facilities at national laboratories and making the scientific case for new or upgraded facilities in the US. An example is the 2002 report from the Office of Science and Technology Policy (OSTP), “Report on the Status and Needs of Major Neutron Scattering Facilities and Instruments in the United States.” (A list of recent previous reports on X-ray synchrotron and neutron facilities appears in Appendix 8.). In contrast to these previous studies, the present study is focused on access to major facilities both in the United States and world wide. The present report is concerned with the availability and mutual access to facilities in Asia, Europe and the US. Other reports that have focused on access to major facilities in Europe and the US are the three OECD reports of 1998 and the National Science Board Report of 1990 (see Appendix 8 for references)

The availability of facilities and the terms of access to them are evolving, as are the organizational and international agreements under which major facilities are constructed and operated. This evolution is often different in different nations and regions of the world, and its impact can vary considerably from one field of science to another. For example, world-class major facilities are being constructed in Japan, China and Australia—a development which will lead to a pronounced shift in the availability of facilities to the East. Similarly, multinational facilities are also evolving. The Institut Laue Langevin (ILL) in France, for example, has evolved from a three-nation facility to a multinational facility with associate members from outside Europe.

The nature of the scientific community that uses these facilities is also evolving and expanding to include many who are less familiar with scattering techniques and with user facilities. Effective access for these scientists will require an introduction to the facility and may also require more assistance in conducting experiments than specialist users needed in the past. A specific aim of this study, therefore, is to articulate this evolution and assess its impact on access for US physicists. What will the picture look like in 2015? How can the US respond to improve access for all scientists in general and for US scientists in particular?

In the future, US scientists may seek access to major facilities outside the US, for several different reasons. Particular facilities may have capabilities or expertise in fields of science that do not exist inside the US. Therefore, US physicists will require access to these facilities, or they will have to leave the field. In other cases, for specific techniques or fields of science, the facilities outside the US may be significantly better than any facility in the US. In these cases, US physicists will seek access to these facilities to conduct world-class science, or that scientific field will no longer be internationally competitive in the US.

As an introduction to the report, the following subsections sketch the nature of the facilities for X-ray and neutron scattering, the fields of science that draw on these facilities, the scientific community using these facilities and the experiments conducted in these facilities. To keep the study manageable, this report is confined to major facilities--large facilities that have open calls for proposals nationally and internationally and have a large “user” program. This report does not discuss the many smaller facilities that have important training programs and play a critical role in establishing a rounded facility base.

1.2. X-ray and Neutron Scattering: Facilities and Science

The use of X-ray and neutron scattering to study matter makes important contributions to physics, chemistry, biology, materials science, engineering, geophysics, environmental science, agriculture and a wide spectrum of interdisciplinary fields. The research has a wide range of goals, as well as diverse applications. To respond to this broad demand, facilities for X-ray and neutron scattering science and engineering are found throughout the world--in North America, Europe and Asia (see Appendix 2 for the list of current X-ray and neutron facilities by region). Some of these facilities are very large. For example, the Advanced Photon Source (APS) at Argonne National Laboratory, the Spring-8 synchrotron facility in Japan, the European Synchrotron Radiation Facility (ESRF) and the Institut Laue Langevin (ILL), both located near Grenoble, France, offer a wide range of modern instruments that enable research in most scientific fields and applications. Some of these facilities, on the other hand, are smaller and can offer only a limited range of instruments. Some of these smaller facilities have also elected to specialize, and they offer unique instruments or unique sample environment facilities. An example of a smaller, specialized facility for neutron scattering is the Hahn-Meitner Institute (HMI) in Berlin, Germany, which has specialized most effectively in ultra-low temperature and high magnetic fields.

In contrast to particle and nuclear physics, the majority of scientists in Europe and the US who use neutron and X-Ray scattering will be able to find a facility and instrument in their own country or region to meet their scientific needs in the future. Unlike US particle and plasma physicists, who may be highly dependent on access to major foreign facilities since the most powerful tools will be located abroad, most US condensed matter scientists will conduct their light and neutron scattering at facilities within the US. However, within specific subfields that use X-Ray and neutron scattering, there are many examples where the best instruments, the best instrument in combination with beam intensity or the best scientific programs may be outside the US. In these cases, access to foreign facilities is essential for US scientists to conduct world-class research.

It is important to acknowledge that US scientists using neutron scattering have been through a period of severe shortage of neutron instruments in the US. However, the availability of US neutron facilities is improving, with the new guide hall at the NIST Center for Neutron Research (NCNR) in Gaithersburg, Maryland; the new instruments at the Lujan Center in Los Alamos, New Mexico; the reopening of the High Flux Isotope Reactor (HFIR) in Oak Ridge, Tennessee; and the coming on line of the Spallation Neutron Source (SNS), also in Oak Ridge. The number of users in the US is small compared to the number of users in Europe. Based on statistics from 2005, there were 1600 users in total in the US. In comparison, there were 2200 users alone at two large facilities in Europe-- ILL in France and ISIS in the UK.

In the same way that US scientists and engineers will want access to the best European or Asian facilities, European scientists state that they want access to the best facilities in the world. (See, for example, the 2005 report from the Council for the Central Laboratory of the Research Councils (CCLRC), "Future access to neutron sources: A strategy for the UK"). Also, US scientists can benefit from international collaborations, which greatly enhance scientific and technical progress for all and broaden horizons. Thus, reciprocal access to foreign facilities in neutron and X-Ray scattering is important to enable the best science world wide and to draw on progress already made and being made outside the US.

It is noteworthy that the majority of publications in neutron scattering (i.e., 70 % in 2000-2006) arise from experiments conducted at the very "largest" facilities (those having the most instruments) in the world. Specifically, 70 % of publications on neutron scattering in leading journals arise from experiments at just four facilities--three in Europe (ILL, ISIS and LLB) and only one in the US (NCNR).

1.3. X-ray and Neutron Scattering: Nature of the Community and Experiments

X-ray and neutron scattering experiments are conducted very differently from particle and nuclear physics experiments. In the X-ray and neutron case, the experiments are short—one to ten days in duration. The scientific teams are small, consisting of two to six scientists, post doctoral associates and graduate students. As noted above, there is a wide spectrum of users from different fields with widely varying familiarity with scattering techniques, some needing substantial assistance to conduct their experiments. There are many users who visit the facility infrequently, perhaps only once or twice a year.

1.4. Complementary Nature of Facilities

When a new facility is constructed or an existing facility is upgraded, the goal is usually to build instruments and sample environment facilities that will be the best in the world for that specific type of instrument and sample environment facility. An additional goal is to construct unique instruments or instruments that are unique in some feature. While some instruments will be standard, such as those needed for routine structure determination, most instruments are not intended to simply duplicate, at a national or regional level, instruments that can be found elsewhere. Only the very largest facilities can offer a full range of instruments.

Facilities are generally complementary, and this is especially true for neutron facilities. In order to take advantage of this complementarity, it is necessary for users to have access to facilities across national and regional boundaries. This point is emphasized in the UK CCLRC report entitled “Future access to neutron facilities”; the first bullet of the Executive Summary states: “UK scientists will continue to require access to the best possible neutron facilities for the foreseeable future.” (See Appendix 8 listing previous reports).

Because of the central role of complementarity, this report explores the degree of complementarity, as well as the means and options for obtaining access to complementary facilities.

1.5. New Facilities

Most new facilities that have opened recently or are planned and have funding for construction will be national facilities (see Appendix 3). Contrary to the initial assumption in this study, most future X-Ray synchrotron and neutron scattering facilities that will be coming on line will be national rather than multinational or regional facilities. These national facilities, especially in Europe, generally seek to be unique or to excel in some particular domain as noted above.

At the same time, the multinational facility ILL has a major upgrade in progress which began in 2000 and is scheduled for completion in 2008. Similarly a major upgrade of ESRF is planned and funding for it is currently being sought. With these upgrades, ILL and ESRF are predicted to be among the leading, neutron and X-Ray facilities in the world for the next 5-10 years (in numbers of users, in number of experiments conducted, and in numbers of publications in prestigious journals). An announcement of a new European Spallation Source (ESS) and the European Free Electron Laser is anticipated in 2008-2010 and new multinational facilities in Russia are possible. Thus we anticipate that access to both national and multinational facilities will be important in the coming decade. The issues involved in mutual access between national facilities in the United States and multinational facilities abroad are discussed further in Section 6, especially 6.1.2. and 6.4.4.

SECTION 2: ORIGIN, SCOPE AND METHODS

This study, “Access to Major International Synchrotron X-ray and Neutron Facilities,” was conducted by a subcommittee of the Committee on International Scientific Affairs (CISA) of the American Physical Society (APS). The three members of the subcommittee are identified in the title page of this report. CISA is a committee made up of members of the APS. It is advisory to the Office of International Affairs within the APS, particularly to the Director of the Office of International Affairs.

In 2003/2004, there was broad interest among the members of CISA in examining how access to major international research facilities, particularly to multinational facilities such as CERN and ILL, was evolving and what access to these facilities might look like in 10-15 years. Initially, the plan was to investigate major facilities in particle, nuclear, synchrotron X-ray, and neutron scattering, but eventually the study focused solely on synchrotron X-ray and neutron facilities. It would now be interesting to compare the findings of this report on X-ray and neutron scattering with how terms of access are evolving in nuclear and particle physics.

The study began with meetings within the APS to define the boundaries of the investigation. The subcommittee first met with the full committee of CISA to gather input and ideas. At the 2005 APS Unit convention, the subcommittee met with the Chairs of the APS Divisions and Forums to introduce the study and to seek input and guidance from the Divisions of the APS. The subcommittee also held a meeting, sponsored by the Forum for International Physics of the APS at the 2005 March Meeting of the APS, to get further member input. The study proposal was presented to the Executive Board of the APS in November 2005 and received formal approval from the Board.

Based on the input from these meetings, it was decided that the study would be limited to *major* international facilities only. These were defined as facilities that held a public call for proposals for experiments, had an annual operating budget of $15 M or greater, and attracted users from across a nation, if not internationally. Specifically, the study excluded smaller facilities that operate as local research facilities and serve predominately one or a few institutions.

To gather information, a web-based questionnaire was sent to major X-ray and neutron facilities worldwide in late 2005. The questionnaire sent to facilities is reproduced in Appendix 4. The 32 facilities responding to the questionnaire are listed in Appendix 6. An Excel spreadsheet of responses to the questionnaire was prepared from the data reported by the facilities. Specifically, data for the years 2004 and 2005 were requested, as well as data from 1998 and 1999. While these data are now two years old, the use of a questionnaire requesting data for a set time period means that the data remain valid even if somewhat dated. The responses to the questionnaires are set out and discussed in Section 4.

Similarly, a web-based questionnaire was sent to user groups and synchrotron X-ray and neutron scattering societies in late 2005 to obtain views of the users of facilities. This questionnaire is reproduced in Appendix 5. The user groups and societies responding to the questionnaire are listed in Appendix 6. Again, an Excel spreadsheet of responses was prepared. The responses to the questionnaire are set out and discussed in Section 5.

In 2005-2007, the three members of the subcommittee held individual interviews with many scientists who use major facilities and with current and previous directors of facilities worldwide. Discussions were also held with individuals in agencies that support facilities. These interviews, both formal and informal, provided important corroboration and meaning to the questionnaire responses, as well as provided additional information. The three subcommittee members and Michele Irwin of the APS Office of International Affairs held conference calls every two to four weeks during 2006 and 2007, when the data from the questionnaires and interviews were analyzed and the report was written.

SECTION 3: NATURE OF USE OF SYNCHROTRON X-RAY AND NEUTRON FACILITIES

This section provides an overview of the user's perspective on synchrotron X-ray facilities and neutron scattering facilities. It outlines how user programs are typically organized today, and it also provides a brief history of user programs at both types of facilities.

3.1. User Programs Today

3.1.1 Proposal Programs

The most common way for a user to obtain access to a facility to conduct an experiment is by submitting a written proposal to the facility. The user typically submits a proposal to conduct a specific experiment on a given beamline or instrument for a fixed number of days. All 32 synchrotron X-ray and neutron facilities responding to the questionnaire (see Section 4) operate proposal programs for their user communities. The percentage of total beamtime allocated through the proposal program at a particular facility ranges from 60% to 100%.

Typically, facilities hold a call for proposals with a specific due date two to four times a year. This call is today sent out by electronic mail to a wide range of individual users, institutions, and user societies. The call is also posted on the facility web site.

In response to the call, proposals are submitted to the facility via the web. The proposals are reviewed by a committee (often termed the Program Advisory Committee or PAC) made up entirely or predominantly of scientific peers from outside the facility. To supplement the review by the PAC, the proposals may also be reviewed by individual scientists from outside the facility who provide a written report. There is also an internal review of proposals for feasibility and safety by facility scientists.

Proposals are then ranked on the basis of scientific merit, effective use of the facility/instrument time, and experimental feasibility. Recommendations for beamtime are made based on the ranking and the amount of time requested compared to the amount of time available on the instrument and the number of highly rated proposals. If a proposal does not receive beamtime, feedback about the unsuccessful proposal is provided to the applicant. The feedback ranges from comments on the science to information on the level of competition for a particular instrument.

Some facilities reserve a portion of time (10-15 % of the total time available) that is awarded to proposals (formal or informal) received between formal proposal calls and for exceptional cases that merit exceptional access. This time is often denoted "Director's Time."

At all but two of the facilities responding to the survey, all proposals--independent of origin--go through the same review process. Once the proposal is ranked on the basis of scientific merit, other factors may come into play in the actual award of beamtime. These factors may include the national origin of the proposal, the presence on the scientific team of at least one collaborator who is a resident in the country (or in one of the member countries of the consortium that funds the facility), and the level of support of the proposal by the local contact at the facility. These factors are discussed in Section 4 ("Responses to Questionnaire to Synchrotron X-ray and Neutron Facilities") and in Section 6.1 ("Basic Access Policies").

In order to disseminate information about a particular facility and the opportunities available at that facility, informational sessions and/or booths are often set up at international, national, and local scientific meetings. Facilities also organize summer and/or winter schools and workshops for new users.

Prior to submitting a proposal, the potential user should always contact the instrument scientist at the facility responsible for the instrument they have an interest in using. One of the main roles of the instrument scientist is to guide users and assist in the eventual experiment. Contact with the instrument scientist is particularly important for new users and for scientists who are expert in their field of research but not in the use of X-rays or neutrons. For example, the user may be unaware of the optimum way to conduct the experiment, which instrument is best suited to the scientific goal, or even if X-rays or neutrons are the most appropriate tools. The instrument scientist can outline what is required to make successful measurements and how the user should prepare for the experiment. Many times, particularly for new users, the instrument scientist can advise on how to write a winning proposal.

The instrument scientist plays a critical role in scientific access to major facilities. The individual who serves effectively in this role must be a research-active scientist able to understand the goals of the user. He or she must have sufficient time to listen to the user with care. The development of a genuine collaboration between the instrument scientist and the users is the ideal situation for producing the best science. The role of instrument scientist will be increasingly important as the user base expands and as scientists who know little about the facilities or the details of a given technique constitute a larger fraction of the total users.

3.1.2 Participating Research Teams

In addition to the process of submitting a proposal, access can also be obtained by building and operating a specific beamline or instrument at a facility. Essentially, a group or institution creates a "Participating Research Team" (PRT) that funds and largely constructs and operates an instrument. PRTs are also called Collaborating Access Teams (CATs) and when we use PRT we include

CATs with the two terms used interchangeably. (In Europe, this team is often denoted a “Collaborating Research Group” or CRG.) PRTs enable the facility to expand the number of beamlines and instruments beyond the number that the facility by itself is able to fund and operate.

Typically, 20% of beamlines or instruments at facilities are constructed by PRTs. However, there is a wide variation in this percentage among facilities and some facilities (e.g., ISIS) do not have PRTs. Because PRTs operate outside the proposal review system, they offer flexible access to PRT members. The PRT is typically allowed to allocate, within the team, 2/3 of the overall time on the PRT instrument.

In recent years, the attitude within the scientific and funding communities about PRTs and CRGs has been mixed. PRTs are currently somewhat out of favor within the US Department of Energy as a result of some specific disadvantages which are discussed in section 6.3.2. However, CRGs at the ESRF are regarded as very successful. As further discussed in Sections 6.1.2 and 6.3.2, CRGs at the ESRF must be constructed and operated within clearly specified guidelines and are subject to review.

3.1.3 Collaboration with Instrument Scientists

In addition to the proposal process and PRTs, a third way to obtain access at a major facility is by collaborating directly with the facility’s instrument scientists. The instrument scientists may have time allocated to them (perhaps 20 % of facility beamtime) or may be able to submit proposals through a separate channel.

3.1.4. Evolution of Access for Users

Historically, use of synchrotron X-ray and neutron facilities in the US has evolved in the following sequence:

(1) Initially, use was by national laboratory scientists directly associated with the facility plus their collaborators in the university or industrial community;

(2) Subsequently, use included groups of scientists from outside the facility who developed and managed certain instruments or beamlines with varying degrees of assistance from the facility. (This approach has evolved into the PRTs of today.); and

(3) General user programs open to all members of the scientific community, with the requirement to submit proposals for specific experiments which are reviewed as noted above in Section 3.1.1.

The percentage of beamtime allocated via these three modes of access was determined by historical circumstances relating to the interest and expertise available in the general scientific community, and by the funding situation in which the facilities have found themselves. All three modes have their advantages and disadvantages (some of which are discussed in Section 6), but all three have proven capable of delivering first-class science.

Mode (1) was the first mode, used when major facilities were first established, particularly in the area of neutron scattering. In the early stages, the expertise with, familiarity with, and interest in these types of experiments existed only among a few university and industrial groups outside the facilities. Because mode (1) entailed the use of the facilities by experts in the field, who were also responsible for developing the field, it led to first-rate, pioneering, and sophisticated science. It also led to an increased awareness of the importance of the scientific potential of these facilities among the scientific community.

Mode (2) allowed expert groups outside the facility to have more formal and guaranteed access. This access was often with new instruments, because the instruments involved were not primarily the creations of the facility scientists. Via mode (2), the suite of instruments at a facility could be expanded beyond the number that the facility could support. In this approach, industrial scientists were drawn to use the facilities in an expanded and more systematic way than before. It also allowed expert scientists in the outside community more freedom to be innovative in the development of new techniques and new types of experiments.

Mode (3) began to be generally used when the scientific community became aware of the importance of these types of experiments and the use of the instruments reached threshold values. Mode (3) was perceived as the most democratic or “fair” method of access to the greatest number of scientists, and thus believed to have the capability of producing the largest quantity of good science. It was also free of the perception of the field being dominated or run by an “old boy” network or cronyism.

Currently, most national and international facilities utilize varying combinations of modes (2) and (3). They use mode (1) only in the initial phases of a new facility.

3.2. History of User Programs at Synchrotron X-ray Facilities

Synchrotron radiation owes its origin to high-energy physics research programs. The development of storage rings provided a major advance in the production of usable radiation as compared to synchrotron sources and led to the development of the first dedicated multi-user facility for synchrotron radiation for soft X-rays in 1968 – the TANTALUS-1 facility at the University of Wisconsin, Madison This was followed by the development of synchrotron-radiation work on soft X-rays at storage rings in Orsay, France; at SURF-II (Synchrotron Ultraviolet Radiation Facility) at the National Bureau of Standards (NBS) in Gaithersburg, Maryland (NBS is now known as the National Institute of Standards and Technology or NIST); and in Japan. Hard X-ray storage ring sources came on line in the 1970s with the 2.5 GeV SPEAR ring (Stanford Positron Electron

Accelerating Ring) on SLAC (Stanford Linear Accelerator Center) at Stanford University; DORIS on the DESY synchrotron in Hamburg; at Orsay, France; at Novosibirsk, Russia; and the CHESS facility (Cornell High-Energy Synchrotron Source) at Cornell University. These hard X-ray synchrotron sources were, however, not dedicated to the production of synchrotron radiation but, rather, were operated in a parasitic mode with high-energy physics experiments as the primary goal. These facilities have become known as the "first-generation synchrotron sources."

In the 1970s, as the first pioneering researchers in solid state physics, atomic physics, and crystallography began to realize the enormous potential of intense beams of X-rays for their research, the demand grew for sources dedicated to synchrotron radiation research. The growing demand in the United States was documented by a 1976 National Research Council study from "The Panel to Assess the National Needs for Facilities Dedicated the Production of Synchrotron Radiation." This study noted an increasing imbalance between demand for synchrotron radiation and its availability. In response to this demand, two dedicated storage ring-based synchrotron radiation sources were constructed in the early 1980s at Brookhaven National Laboratory (the National Synchrotron Light Source (SLS) Soft X-ray and Hard X-ray rings). In addition, a new 1 GeV storage ring at Madison, Wisconsin was commissioned to replace TANTALUS-I. Similar considerations abroad led, during the same period, to the commissioning of other dedicated sources such as the Synchrotron Radiation Source (SRS) at Daresbury, England; the Laboratoire pour l'Utilisation du Rayonnement Electromagnitique (LURE) facility at Orsay, France; the Photon Factory in Tsukuba, Japan, which was founded as a facility for University researchers to carry out experiments using synchrotron radiation ; and the Berliner Elektronenspeicherring-Gesellschaft fur Synchrotronstrahlung (BESSY) soft X-ray facility in Berlin, Germany. These so-called "second-generation synchrotron sources" were dedicated to the production of synchrotron radiation primarily from the bending magnets of the storage ring.

Meanwhile, driven by the same demand, some of the first-generation facilities gradually evolved toward second-generation status by means of upgrades and agreements with laboratory managements to dedicate a fraction and sometimes all of the yearly machine operations to synchrotron radiation as the high-energy physics frontiers advanced. This resulted in the establishment of Stanford Synchrotron Radiation Laboratory (SSRL) at SLAC at Stanford and Hamburger Synchrotronstrahlungslabor (HASYLAB) at Deutsches Elektronen-Synchrotron (DESY) in Hamburg. All these second generation facilities established user programs with various combinations of systems involving a Program Advisory Committee which allocated beamtime for general users, and Participating Research Teams (PRTs) who managed the greater share of time on their own beamlines.

Because X-rays and UV sources as research tools had been familiar to scientists for over half a century, the use of soft and hard X-rays for spectroscopy and crystallography had a natural constituency in the large community of researchers who carried out similar studies on more modest scales at their own laboratories. The power of hard X-rays as a tool for protein crystallography rapidly began to become apparent to the life sciences community. Similarly, the enormous possible improvements in small angle X-ray scattering experiments began to be realized by the materials science, soft condensed matter, and chemistry communities. Finally, the more esoteric X-ray scattering experiments on condensed matter were rapidly embraced by the community of people who had been carrying out similar studies using neutron scattering from the 1960s onwards.

In this period (roughly 1975 to 1995), the number of synchrotron source users grew into the thousands, spread across many disciplines at the various synchrotron facilities, enabled by the large number of available beamlines and the rapid turnaround times resulting from the high intensities of the X-ray beams. Thus, the synchrotron sources developed inevitably as user facilities instead of as facilities in which a small group of researchers dominated their use for a narrow field of scientific research.

Nevertheless, the initial (and often later) periods of these sources were dominated by teams of pioneering researchers in some of these fields who had the expertise and skill to exploit usefully the new capabilities, known as Participating Research Teams (PRTs) or Collaborative Access Teams (CAT's). (We will use the terms PRT and CAT interchangeably.) These PRTs were dedicated to research spread out over several fields and techniques.

Over time, the formal dedication of the largest fraction of beamtime has shifted gradually from the PRTs to the general individual user. This continuous and still-ongoing process is driven, in part, by financial considerations as the cost of constructing and maintaining beamlines has become ever more expensive.

In the 1980s, driven by the ever-growing demand for beamtime from the above communities and the recognition of the need for higher brightness to carry out research at the cutting edge, the construction of a new generation of dedicated synchrotron X-ray sources was recommended by the Seitz-Eastman Panel of the National Research Council. These insertion-device based sources, with increases in the brilliance of the X-ray beams by many orders of magnitude, were constructed in the US in the 1990s as the Advanced Photon Source (APS) at Argonne National Laboratory, primarily for hard X-rays, and the Advanced Light Source (ALS) at Lawrence Berkeley Laboratory, primarily for soft X-rays. Similar sources were commissioned in Europe (the ESRF at Grenoble, France) and in Japan (the Super Photo Ring – 8 GeV (SPring-8) facility at Harima, Japan). Later, these were joined by the Swiss Light source (SLS) in Villigen, Switzerland, MAX-II in Lund Sweden and BESSY-II in Berlin. These are the “third-generation synchrotron sources.”

The U.S. synchrotron facilities currently attract over 8,000 users per year on the average, among whom the protein crystallographers are perhaps the most rapidly growing community. The numbers are similar for Europe and Japan. The facilities each have a mix of PRTs (CATs) and general user programs, but cannot by any means be said to be dominated by any one group of users or in-house scientists. Upgrades of existing second-generation facilities and construction of new synchrotron facilities around the world have, by now, resulted in a number of third-generation synchrotron X-ray facilities in Europe and the United States. At the same time, less brilliant synchrotron sources have been, or are being, constructed in several other countries around the world.

It is interesting to note that machines originally built for particle physics research have evolved to serving very different communities of scientists, such as condensed matter scientists, materials scientists, chemists, geologists, and, increasingly, biologists. To some extent this has driven a certain degree of separation between those who run the accelerators, those who develop and maintain the instrumentation on the beamlines, and those who carry out the scientific research. The latter group, as it grows, will most probably increasingly consist of those who are more interested in the results pertaining to their scientific interests than in the subtleties of the instrumentation or the scattering techniques. This may lead to problems in the future unless scientists coming into the field are exposed to a broad education on all aspects of this endeavor.

Future X-ray sources will be of three types:

- Storage Rings with optimized capabilities, such as the one planned as a replacement for the National Synchrotron Light Source (NSLS) at Brookhaven National Laboratory (BNL), to be known as NSLS-II, and PETR III at HASYLAB at DESY in Germany;
- the X-ray Free Electron Laser (XFEL) sources, such as the source under construction at Stanford University in the United States, the sources under construction at Hamburg (and possibly also at Berlin in the future) in Europe, and in Japan; and
- the so-called Energy Recovery Linac (ERL) ring sources currently being planned (but not yet approved) for CHESS at Cornell University and under consideration for the upgrade of the APS at Argonne National Laboratory.

The latter two sources, will offer several important advantages. They will provide many orders of magnitude increase of brightness over even third-generation sources, as well as radiation that is almost completely coherent and can be in the form of short pulses of the order of 10 femtoseconds. These sources will thus offer unique opportunities for new kinds of science. They may attract totally new communities, such as chemists or atomic physicists interested in femtosecond spectroscopy or highly non-linear processes, as well as scientists interested in X-ray studies of matter under extreme conditions of temperature or density.

The XFEL sources will initially have only a few beamlines and will thus probably cater to a specialized community, rather than to the great majority of current synchrotron users. Over time, this mix of users may evolve.

The ERL sources will have lower brilliance than the XFEL sources.
They will more closely resemble the current synchrotron X-ray sources, with many beamlines (but with the advantages of higher brilliance, coherence, and short pulses). The ERL sources are expected to draw on the current communities for their user base.

3.3. History of User Programs at Neutron Scattering Facilities

Neutron scattering science began in the national laboratories of the world. The early sources of neutrons were nuclear reactors, and those sources intense enough to conduct neutron scattering studies were in the national laboratories. The nuclear reactors were multipurpose, with a primary focus on research for nuclear power, nuclear weapons, and isotope generation. Neutron scattering science was an “add-on,” a side or an additional benefit.

The scientists who conducted the neutron scattering experiments were national laboratory staff members. For example, from the late 1940s to 1960, both Clifford Shull and Bertram Brockhouse did their pioneering research, which led to the 1994 Nobel Prize in Physics, when they were physicists on staff at Oak Ridge National Laboratory (ORNL) and at Chalk River Laboratories, respectively.

Many scientists in universities and corporate laboratories are familiar with X-rays and use them in their science. With very few exceptions, scientists in universities and corporate laboratories did not have a corresponding familiarity or use of neutron scattering. Thus, a deliberate program to involve scientists outside the national laboratories and beyond the security of atomic energy programs was required to make this important research tool widely available and to create a user community and user programs in corporations and universities.

In the 1950s, many research reactors were constructed in the United States to support Atomic Energy Commission (AEC) research programs (now included within DOE programs). These reactors included the Chicago Pile 3 (CP-3) and Chicago Pile 5 (CP-5) at ANL and the graphite reactors at ORNL and BNL. Research at these facilities was conducted by

AEC laboratory staff scientists, and any external users were collaborators with AEC staff.

The reactors were often funded by contributions from individual units or cost centers within the laboratories and the AEC. They were not funded centrally, which would have more naturally supported an external user facility. Indeed, one of the reasons for closing several reactors some years later was that individual programs that were supporting the reactors wished to direct their funds elsewhere, and financial support was withdrawn (e.g., CP-5 was closed circa 1980).

During the 1950s, neutron scattering in the United States was done exclusively in AEC laboratories (including those in Ames, IA; Argonne, IL; Brookhaven, NY; Los Alamos, NM; Idaho; and Oak Ridge, TN). There were, however, some collaborations with scientists from university and corporate laboratories. For example, the spectrometers at BNL were used by Columbia University and Bell Laboratories.

In the 1960s, a second generation of reactors was constructed in the United States—the High Flux Beam Reactor (HFBR) at BNL (1965), the High Flux Isotope Reactor (HFIR) at ORNL (1966), and the Neutron Beam Split Core Reactor (NBSR) at NBS (now NIST) (1969). The HFBR and NBSR were devoted primarily to neutron scattering, and the HFIR was devoted primarily to isotope production (but also with high-intensity neutron beams). These facilities provided US scientists with high-intensity and reliable neutron beams and modern instruments. They enabled the United States to lead or be at the cutting edge in neutron scattering science in essentially all fields of condensed matter physics.

It is also interesting to note that construction of a large 100 MW research reactor, the Argonne Advanced Research Reactor (AARR) at ANL, was started at the close of the 1960s, but construction was terminated shortly after ground breaking. Going into the 1970s, scientists outside national laboratories increasingly recognized the value of neutrons as a tool, and an increasing number of outside scientists established collaborations with laboratory scientists to use AEC and NBS facilities. Visitor programs were set up at the laboratories, but external users were generally collaborators (not users). These connections were established informally rather than through formal user programs.

The first formal user program with beamtime funded and set aside explicitly for external users appears to have begun in Europe. In the United Kingdom in the mid-1950s, the Atomic Energy Research Establishment (AERE), which operated neutron facilities, and the Department of Scientific and Industrial Research (DSIR), which funded research and graduate education in universities, established an agreement. Through this agreement, DSIR provided funds and AERE set aside a portion of its neutron beamtime and neutron scattering facilities for use by university scientists. This agreement and the DSIR support opened access to AERE facilities at Aldermaston and Harwell for university scientists. A number of students received their PhD degrees in neutron scattering at the DIDO reactor at Harwell in the late 1950s and early 1960s, going on to careers in neutron scattering both in and outside national laboratories.

In France, the Commissariat d’ Energie Atomique (CEA) established a neutron scattering center in Saclay (Paris) in 1952 with the EL2 reactor and later the EL3 reactor with a cold source. In 1956, the CEA created a site at the Centre Etudes Nucleaires de Grenoble (CENG) with reactors Melousine and Siloue. Louis Neel, joint director of CENG and of the Centre National de Recherche Scientifique (CNRS) in Grenoble, played a key role in extending use of neutrons beyond the CEA and into CNRS laboratories. Many European nations, such as Sweden, Denmark and Holland, also established national facilities.

Development in Germany was somewhat different, because nuclear research was forbidden until 1955, and there was no atomic energy agency. In 1956, professor Maier-Leibnitz purchased a 1 MW reactor from General Electric (GE) for the Technical University of Munich. Again, many students received their PhD degrees using these European reactors. In 1961, the Karlsruhe Nuclear Research Centre constructed a 15 MW research reactor. In 1962, two British reactors (DIDO type 10 MW and 23 MW) were purchased at the German research center in Jülich. At a historic Geneva Conference on the Peaceful uses of Atomic Energy in 1964, French and German research ministers agreed to build a joint neutron facility. On January 19, 1966, a treaty was signed to construct the Institut Laue Langevin (ILL) in Grenoble. ILL was created as a symbol of French and German cooperation following the Second World War.

ILL opened in 1972 as the world’s first full, independent, user neutron facility funded and dedicated entirely for neutron science, primarily for external users from the scientific community (as well as ILL scientists). Access to ILL was obtained by written scientific proposal, with beamtime awarded based on scientific merit as described in Section 3.1. ILL was independent from any atomic energy agency and sited outside the CEA gates, a feature regarded as critical in making ILL more accessible to the user community. ILL paid the travel and accommodation costs of the users, a feature seen as centrally important. The instrument scientists at ILL were regarded as the key scientific and technical link between the user and ILL, and they were critically important to successful user experience and experimental outcome. The British joined ILL in 1973 following an unsuccessful attempt to establish a high flux reactor in the United Kingdom. It took several years for ILL to develop instrumentation and a user community. By the end of the 1970s, however, it had become fully competitive in distinction and in breadth of science, and it had become superior in numbers of users, including users in soft condensed matter.

In a clear break with the past in the United States, the Intense Pulsed Neutron Source (IPNS) at ANL opened in 1981 as the first full user facility dedicated entirely to neutron science in the United States and modeled after the ILL. The IPNS as a facility grew out of the Zero-gradient synchrotron (ZGS) Intense Neutron Generator projects (ZING-P and ZING-P') developed within ANL. IPNS opened with written proposals for beamtime that were reviewed by external review committees for scientific merit. Also in 1981, the Small Angle Neutron Scattering (SANS) facility at the HFIR reactor opened as a user facility. This SANS facility was supported by the National Science Foundation (NSF) and was the component of the HFIR programs that was a formal user facility. (NSF support terminated in 1989 because HFIR was often not available in the late 1980s, as discussed below.)

In 1983, a NRC study of neutron facilities in the United States noted that there were four major neutron facilities operating in the United States: HFBR at Brookhaven, HFIR at Oak Ridge, NBSR at NBS (now NIST), and the IPNS at Argonne. Each had approximately 100 users. Two other facilities, the spallation source at LANL (which has since grown into the Manuel Lujan Neutron Scattering Facility at Los Alamos Neutron Science Center (LANSCE)) and the MURI had together another 100 users, for a total of 500 users in the United States. The total number of users at these six US facilities was approximately the same number of users (650) as at ILL in 1982.

Other facilities soon initiated formal user programs. By 1985, for example, LANSCE had a user program with written proposals that were reviewed by the same external committees that reviewed proposals to IPNS. The LANSCE program, however, was hindered by unreliable operation. The Cold Neutron Research Facility (CNRF) at NIST opened with a new guide hall and suite of instruments in 1990 as a full user facility. This facility, now called the NIST Center for Neutron Research (NCNR), currently has the largest number of users in the United States, largely because of its modern suite of cold neutron instruments. From a user's perspective, the resources devoted to guide halls and instruments enormously expand the availability of neutrons. The HFBR at Brookhaven began a user program around 1990, with part of the beamtime accessible via written proposals that were reviewed by external committees.

Beginning in the mid-1980s, a changing regulatory environment in the DOE led to less predictable operation for HFBR and HFIR. Both facilities, previously highly reliable, became unpredictable and were often down under review. During this period, there were few upgrades in terms of new instruments or guide halls, and HFIR and HFBR did not grow into broader-use neutron scattering centers. Indeed, this was a very low period of neutron availability and a difficult time for the user community in the United States, especially compared to Europe. HFBR last operated in 1997, and HFBR was closed permanently by DOE in 1999. This was a major loss. During this same period, HFIR has often been down, and when it reopens, with its new cold source and guide hall as part of a combined facility with the SNS, it will be a full and highly welcome user facility.

The history of neutron scattering facilities, of instruments, and of the number of users at US facilities and abroad can be found in the OSTP “Report on the Status and Needs of Major Neutron Scattering Facilities and Instruments in the United States” (2002). Because this information has already been compiled by OSTP, the goal of this American Physical Society report is, rather, to sketch the history and the evolution of user programs.

The nature of the user has also evolved, from being largely neutron scattering professionals in national laboratories to being predominantly users from outside the national laboratories who are experts in their own disciplines but often not experts in neutrons. This evolution is continuing. The occasional and less-experienced user of neutrons will therefore rely increasingly on the insight and scientific judgment of the instrument scientists at facilities to take best advantage of neutrons, to design penetrating experiments, and to succeed in collecting their results. This will be particularly so as data-acquisition rates increase and experimental times shorten. Thus, while instrument scientists were seen as critical in the first full user facility in 1972, they play an even more critical role today in successful access to neutron facilities.

SECTION 4: ANALYSIS OF RESPONSES TO QUESTIONNAIRE TO FACILITIES

4.1. Nature of Facilities: National, Multinational, and Availability

All but three of the 32 synchrotron X-ray and neutron facilities responding to the questionnaire identified themselves as national facilities (see Appendix 6 for list of facilities responding to the questionnaire). The three exceptions are ESRF and ILL in Europe and the Frank Laboratory of Nuclear Physics in Russia (a reactor-based neutron scattering facility). The remaining facilities responded that they are national facilities with construction and operating budgets provided by a single nation. In addition, most of the very large and important facilities soon coming on line in Asia are national facilities (e.g., J-PARC in Japan and CARS in China) (see Appendix 3).

Thus, this survey finds that, at least for synchrotron X-ray and neutron facilities, there is not a clear trend toward multinational or regional facilities and away from national facilities. This finding contradicts the findings outlined in the Report of the OECD Megascience Forum on “Access to Large Scale Research Facilities.” The OECD study reported that there is a “further concentration of research at a small number of very large research facilities that are built and operated on a regional or international basis…” While this trend towards regional or international facilities may be true in other fields of science, the questionnaire discussed in this report reveals that most new synchrotron X-ray and neutron facilities will be national facilities.

At the same time, ESRF, ILL, and the Frank Laboratory are very important exceptions because of their large size and the fact that they play such a significant role scientifically. For example, ESRF has 50 beamlines, and today has the largest proposal submission and acceptance program, the largest number of users, and the largest publication portfolio in major international journals (but not in all journals) of all synchrotron X-ray facilities in the world. Similarly, among neutron facilities, ILL has the largest number of instruments (indeed in 2007 only slightly less than the total at all US neutron facilities combined), the largest proposal and user programs, and the largest publication portfolio. ESRF and ILL also have some unique instruments and instruments which combine high beam intensity with excellent properties that make them the facilities of choice for many experiments. With the “Millennium Program” upgrades in progress at ILL since 2001 and the upgrades proposed for ERF, these two facilities are anticipated to remain world leaders for the next 10 years.

In addition to ESRF, ILL, and the Frank Laboratory, Elettra, HASYLAB, St. Petersburg, BESSY, and BSRF are multinational facilities. Also, among future facilities, the European X-Ray Free Electron Laser (XFEL) under construction in Hamburg and the European Spallation Source (ESS) are multinational facilities.

Thus, it will be important for the United States to develop policies that will enable flexible access for US scientists to multinational facilities.

The difference between access policies of national and multinational facilities is set out in Section 6.1. The mismatch of bilateral policies and multinational facilities is also discussed in Section 6.1, as well as in Section 6.4.

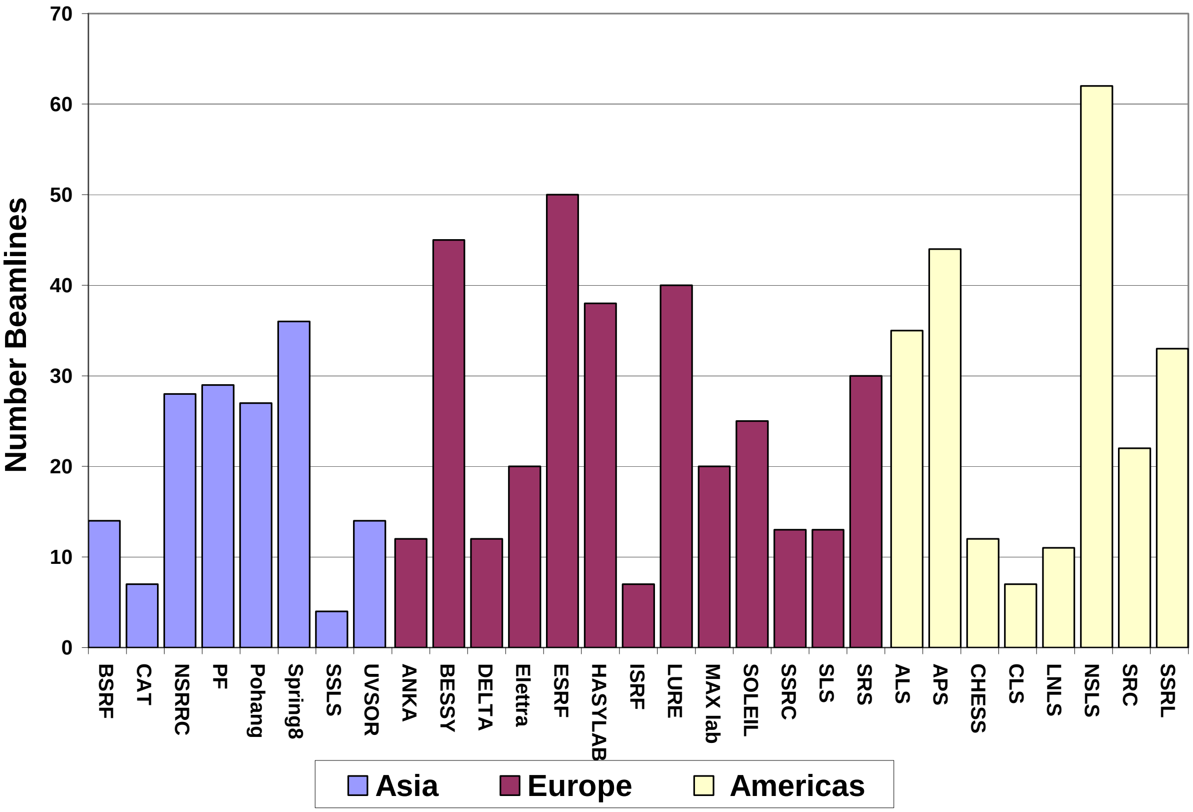
4.2. Access by Scientific Proposal

All of the 32 facilities responding to the questionnaire stated that access to the facility was obtained by submitting a written proposal for beamtime. The proposals are reviewed by external review committees, with recommendations for beamtime made by the committees based on scientific merit. This access process is described further in Section 3.1.1. Scientific review by external committees is now clearly a universal, worldwide practice and is anticipated to continue. After the scientific review is completed, other considerations enabling or limiting access to beamtime may enter the decision-making process, as discussed below and in Section 6.1.

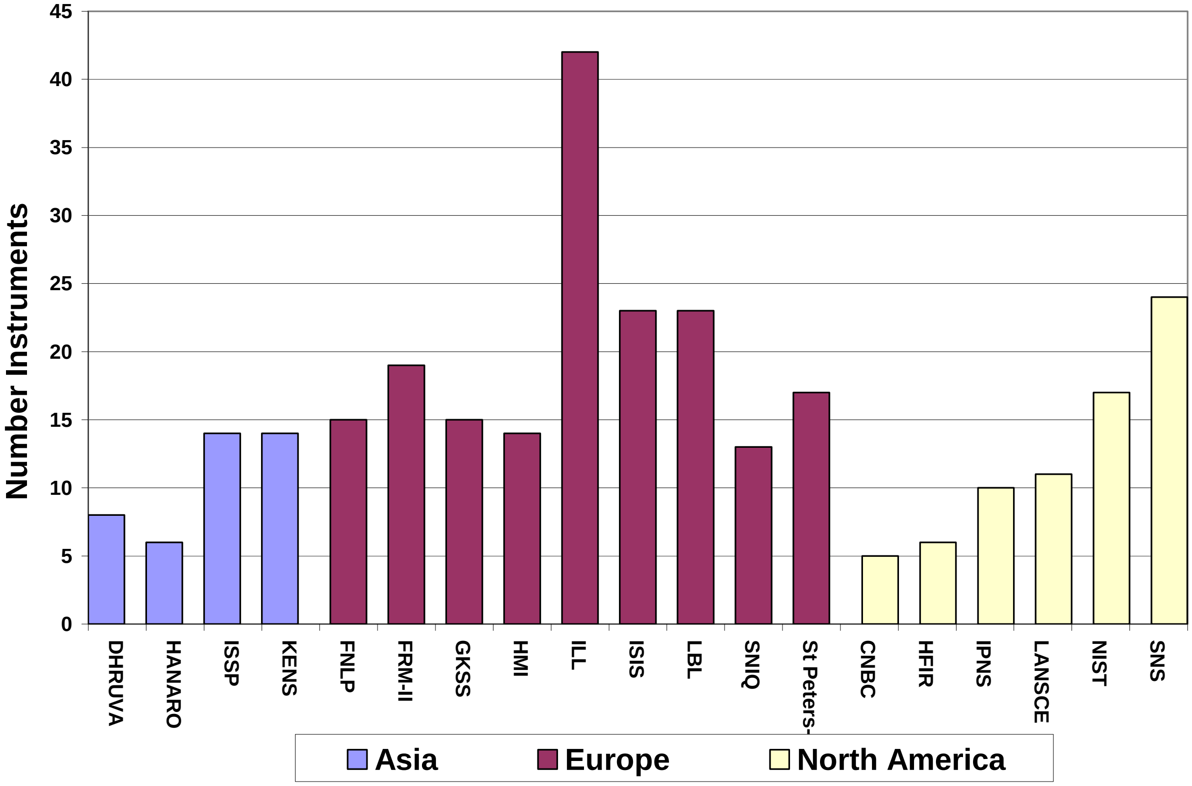
4.3. Availability of Facilities

In Figure 4.1 (see below), the number of beamlines at synchrotron X-ray facilities and of instruments at neutron facilities is set out for the three regions, Asia, Europe, and the Americas. The goal is to give an impression of the distribution of availability of synchrotron X-ray beamlines and neutron scattering instruments throughout the world.

This figure includes the major facilities responding to the questionnaire (see Appendix 6 for this list). The figure also includes the other major facilities that could be identified in early 2007. In many cases, the number of instruments or beamlines was obtained from facility websites and/or by contacting the facility directly. It does not include some important facilities that opened very recently, such as Diamond.



Number Synchrotron Beamlines by Region



Number Neutron Instruments by Region

Figure 4.1. Number of synchrotron X-ray beamlines and neutron scattering instruments in 2007.

There is approximately the same number of synchrotron X-ray beamlines available in Europe and in North America (chiefly in the United States). From discussions with users, the availability of beamlines in the United States has been regarded as generally good. There has not been a significant drive by US scientists to seek beamlines abroad. For example, the percentage use of beamtime at ESRF by US scientists was approximately 3% in 2007.

The situation is quite different for the distribution of neutron scattering instruments. The number of neutron scattering instruments available in 2007 in the United States (approximately 70) is significantly less than that in Europe (approximately 200). Note that the 70 instruments listed for the United States include the 24 instruments planned for the SNS when the full suite of instruments at the first target station is completed.

In analyzing the availability of neutron facilities, factors beyond just the number of instruments are important. For example, with the high neutron beam intensity and the sophistication of the instruments at the SNS, the United States will make a significant step forward. At the same time substantial improvements in instruments are taking place elsewhere. In 2004 and 2005, scientific activity did scale well with the number of instruments (see below).
It is interesting to note that the current number of instruments at ILL (42) and ISIS (23) alone is comparable to the total number in the United States, including the 24 at SNS. In Europe, in addition to ILL and ISIS, there are several very significant, independent facilities (e.g., LLB and FRM-II, see Figure 4.1). The number of inelastic neutron scattering instruments in the United States is particularly small.

In summary, it is anticipated that, for the next 10 to 15 years, there will remain more than twice as many neutron scattering instruments in Europe than in the United States. A similar conclusion was noted in the 2002 OSTP Report on neutron scattering facilities in the United States. Thus, the second target station at SNS, the new guide hall and instruments (5) at NIST, the new guide hall and instruments at HFIR, and the new instruments at LANSCE are highly welcome. The funding of guide halls, new instruments, and instrument upgrades yields large increases in facility availability. As discussed below, the present survey suggests that the number of users, the number of accepted proposals, and the number of publications, with some variations, all scale with the number of instruments. The emphasis on instruments has been the underlying reason for the success of NIST and ILL, and it is a primary reason for their large user programs. At NIST, for example, approximately 2/3 of the operating budget supports the guide hall and instruments, while 1/3 supports the reactor or neutron source.

4.4. Number of Proposals Submitted and Accepted at Selected Facilities

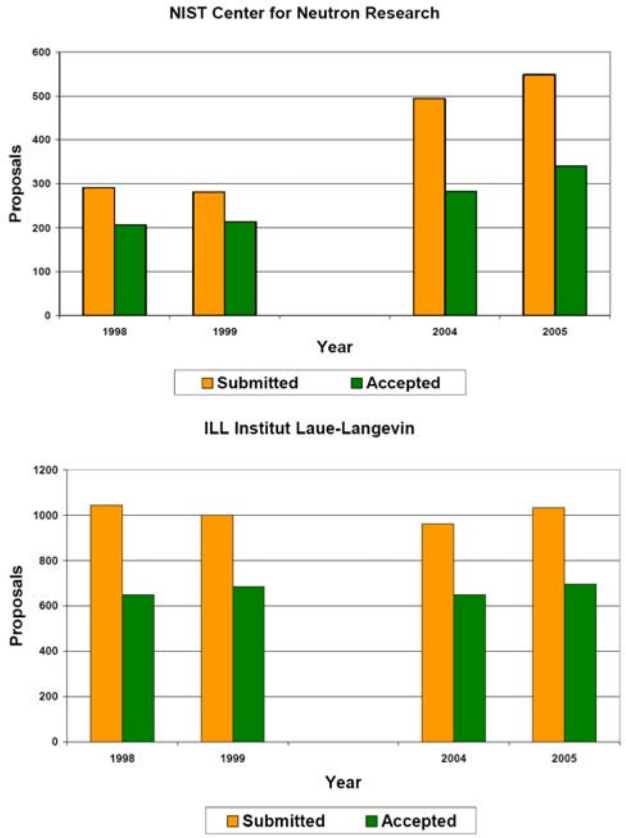


Figure 4.2. The number of submitted and accepted proposals at NIST and ILL.

Figure 4.2 shows the number of proposals submitted and accepted at the NIST Center for Neutron Research (NCRC) and at the Institut Laue Langevin (ILL), both nearly ten years ago and more recently. The increase in the number at NIST between 1998 and 2005 reflects two factors: the increase in number of instruments in the user program, from 13 to 17, and the increase in “instrument days delivered” between 1998 and 2005 (see the 2002 OSTP Report). At ILL, the number of proposals has changed little between 1998 and 2005, reflecting its stable operation. The ratio of accepted to submitted proposals is also similar at NIST and ILL, as it is also at other neutron scattering facilities. More data on how the number of accepted proposals, users, and publications scales approximately with the number of instruments are presented below.

Turning to a similar analysis for selected synchrotron X-ray facilities, the number of proposals submitted and accepted at the ESRF in Grenoble and at the NSLS at Brookhaven National Laboratory is shown below in Figure 4.3. These synchrotron X-ray facilities were selected for this analysis, because ESRF has the largest user program in Europe, and NSLS has one of the largest user programs in the United States. The operating budget of ESRF is 2.5 -3 times that of

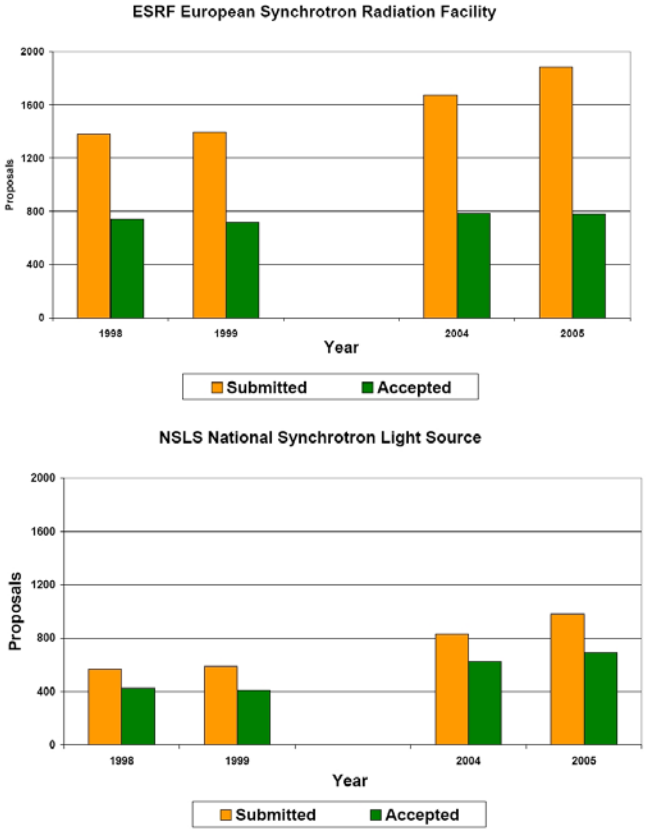


Figure 4.3. Number of proposals submitted and accepted at ESRF and NSLS.

NSLS. The number of proposals submitted and accepted at ESRF has increased significantly between 1998 and 2005, reflecting the continuing development of ESRF. The ratio of the number of proposals accepted to submitted has decreased between 1998 and 2005 showing a clear increase in competition for beamtime at ESRF. The ratio of accepted to submitted proposals in 2004, averaged over all synchrotron X-ray facilities, was 0.636 in Europe and 0.625 in the United States. For comparison, the accepted-to-submitted ratio at neutron scattering facilities was 0.711 in Europe and 0.642 in the US.

The accepted-to-submitted ratio is not the same for all instruments. From discussions with users and facility directors, when the ratio of accepted to submitted proposals falls to the range of 0.5 to 0.3, users tend to turn to other research. On some instruments at APS and ESRF this ratio has dropped to as low as 0.15, unacceptably low.

4.5. Level of Scientific Activity and the Number of Instruments

The number of accepted proposals, the number of users, and the number of publications in select journals provide an indication of scientific activity at a facility. These indicators are useful both in comparing specific facilities and comparing facilities in different regions of the world. For example, the number of accepted proposals per year provides an estimate (a lower limit) of the number of experiments conducted per year.

The number of accepted proposals does not include experiments done within PRTs, because PRT experiments are outside the proposal program. It does not include experiments done by instrument scientists at facilities in which the facility allocates a percentage of time to instrument scientists, such as at ESRF and ILL. At some facilities, there are few or no PRTs (e.g., ISIS), and at some facilities, instrument scientists must submit proposals to conduct experiments along with external users (e.g., ISIS, NIST). At ISIS, for example, the number of accepted proposals provides a good estimate of the number of experiments conducted. There are generally more PRTs at synchrotron X-ray facilities than at neutron facilities.

Table 4.1 lists the number of proposals accepted, the number of beamlines or instruments, and the ratio of the two at the 32 facilities responding to the questionnaire, in Europe, the Americas (chiefly the United States), and Asia in 2004. The number of accepted proposals and beamlines and the ratio at synchrotron X-ray facilities is similar in Europe and the Americas. However, the number of accepted proposals at neutron scattering facilities in the Americas was approximately one third that in Europe in 2004. The competition for instrument time was also greater in the Americas (see ratio in Table 4.1) in 2004. The data in Table 4.1 for Asia is not representative, because only three synchrotron X-ray facilities and one neutron facility responded from Asia. Clearly, there was significantly more neutron scattering research done in Europe than in the United States in 2004. The data were similar in 2005.

Ratio of Accepted Proposals to Beamlines or Instruments: 2004

Synchrotron X-ray Facilities

	Accepted	Beamlines	Ratio
Europe	2,617	264	9.9
Americas	2,355	206	11.4
Asia	1,826	77	23.7
Total	**6,798**	**547**	**12.4**

Neutron Facilities

	Accepted	Instruments	Ratio
Europe	2,337	203	11.5

Americas	833	49	17.0
Asia	226	14	16.1
Total	**3,396**	**266**	**12.8**

Table 4.1. Number of proposals accepted, number of beamlines or instruments, and the ratio of accepted proposals to beamlines or instruments at synchrotron X-ray and neutron facilities in 2004 by region of the world.

Selected Ratio of Accepted Proposals to Instruments: 2004

	Accepted	Instruments	Ratio
NIST	282	17	16.6
ILL	650	42	15.5
ISIS	665	23	28.9
Lujan	221	11	20.1
CNBC	63	5	12.6
LLB	323	23	14.0
Total	**2,204**	**121**	**18.2**

Selected Ratio of Accepted Proposals to Beamlines: 2004

	Accepted	Beamlines	Ratio
APS	538	44	12.2
SRS (Darsbury)	488	30	16.3
NSLS	694	62	11.2
ESRF	786	50	15.7
Total	**2,506**	**186**	**13.5**

Table 4.2. Number of proposals accepted, number of beamlines or instruments, and their ratio at selected synchrotron X-ray and neutron scattering facilities in 2004.

The number of accepted proposals per year appears to be set chiefly by the number of beamlines or instruments. The average ratio of accepted proposals per beamline at X-ray facilities is 10-12 (see Table 4.1). For some synchrotron X-ray facilities, the ratio is as high as 15-20 (see Table 4.2). The ratio of accepted proposals per year per neutron scattering instrument in 2004 at a typical facility was 13-20. The ratio was similar in 2005, with a ratio of 20 at NIST and 17 at ILL. It is higher at ISIS, because nearly all instrument time is covered by proposal at ISIS, as noted above.

Selected Ratio of Users to Instruments: 2004

	Users	Instrument	Ratio
NIST	854	18	47.4

Lujan	262	11	23.8
ILL	1,164	42	27.7
ISIS	1,000	23	43.5
Total	**3,280**	**94**	**34.9**

Selected Ratio of Visitors to Instruments: 2004

	Visitors	Instrument	Ratio
IPNS	438	10	43.8
Lujan	450	11	40.9
ILL	1,679	42	40.0
ISIS	1,500	23	65.2
Total	**4,067**	**86**	**47.3**

Table 4.3. Number of users and visitors per year, the number of instruments, and their ratio at selected neutron scattering facilities in 2004.

The number of users and visitors per year, along with the number of neutron scattering instruments at selected facilities, is shown in Table 4.3 for 2004. A user is defined as a scientist who conducts an experiment at the facility but is counted only once per year, irrespective of the number of experiments conducted by the user per year. A visitor is defined as a user but each visit to the facility to conduct an experiment is counted.

There are typically 40 users per year per instrument at neutron scattering facilities. In 2002, the number of users per instrument was approximately 40 at ILL and NIST, and it was 60 at ISIS (2002 OSTP Report, p. 30). Similarly, there are typically 40-65 visitors per year per instrument (see Table 4.3).

The number of users and visitors per beamline at synchrotron X-ray facilities is definitely larger, 40-80 and 100-200, respectively (see Table 4.4). The larger number arises because the X-ray experiments are generally shorter because the beam intensity is higher and the teams conducting X-ray experiments are larger. There are typically 2.5 - 5 users per accepted proposal for synchrotron X-ray facilities and 1.5 - 2 for neutron scattering facilities. These larger numbers probably reflect the fact that synchrotron X-ray experiments are currently less automated and more “hands on” than neutron experiments.

Selected Ratio of Users to Beamlines: 2004

	Users	Beamlines	Ratio
APS	2,773	44	63.0
NSLS	2,299	62	37.1

ESRF	4,008	50	80.2
Total	**9,080**	**156**	**58.2**

Selected Ratio of Visitors to Beamlines: 2004

	Visitors	Beamlines	Ratio
APS	8,459	44	192
SRS (Darsbury)	2,189	30	73
SLS (Swiss)	1,443	7	206
ESRF	5,488	50	110
Total	**17,579**	**131**	**134**

Table 4.4. Number of users and visitors per year, the number of beamlines, and their ratio at selected synchrotron X-ray scattering facilities in 2004.

It is interesting that the number of accepted proposals per instrument at ILL, NIST, and ISIS is 17, 19, and 25 respectively in 2004. These are very similar numbers. It is somewhat larger at ISIS than ILL, because, at ISIS, instrument scientists must submit proposals like everyone else to conduct experiments, and nearly all instrument time is covered by a proposal. NIST has a similar policy that all beamtime is allocated through proposals, with NIST scientists and NCNR instrument scientists having access to a separate proposal program. At ILL, 20% of all beamtime is allocated to instrument scientists outside the proposal program.

Based on these data, the number of accepted proposals seems to be a good measure of scientific activity—better than the number of users. For example, there is a significant variation in the number of users per accepted proposal (per experiment) among neutron scattering facilities (e.g. 1.2 at Lujan, 1.8 at ILL, and 3 at NIST) and between synchrotron X-ray and neutron facilities.

These data suggest the level of scientific activity, as indicated by the number of accepted proposals for experiments and the number of users, is set largely by the number of instruments or beamlines available at facilities. For comparable sources, the availability of neutron scattering and synchrotron X-ray facilities is highly correlated with the number of instruments.

If a policy goal is to expand availability and to increase the level of use of major facilities within the scientific community, then the most direct way to do this is to increase the number of instruments and to devote resources to new guide halls and instruments at existing facilities. In particular, some European facilities have created and maintained large user bases by devoting resources to major instrument upgrades and expansion throughout the life of the facility.

4.6. Facilities Have User Organizations

Most facilities responded that the scientists and engineers who conduct experiments at their facilities have a user organization (often referred to as a user group). Indeed of the 31 facilities that responded to this part of the questionnaire, all except six have user groups. The user groups usually operate quite independently of the facility. The goals of user groups and user societies, along with their characteristics and interests, are discussed in Section 5.

The six facilities that do not have user groups are LNLS, ILL, SINQ, Jülich, St. Petersburg, and IPNS. ILL and its users probably do not feel the need of a distinct user group, because ILL is closely coupled with the European Neutron Scattering Society and with other national neutron scattering societies of Europe. SINQ is closely coupled to the Swiss Neutron Society. IPNS did have a very active and large user group, indeed probably the first in the United States.

4.7. Facilities Do Not Charge User Fees

At all of the 32 responding facilities, use of the facility is free of charge for research that will be in the public domain. It can be said, universally and globally, that there are no user fees at either national or multinational facilities for research that will be published in the open literature. Experience worldwide at user facilities has shown that the facilities need an independent operating budget with users bringing science and people to the facility to conduct experiments and analyze the data subsequently at their home institutions.

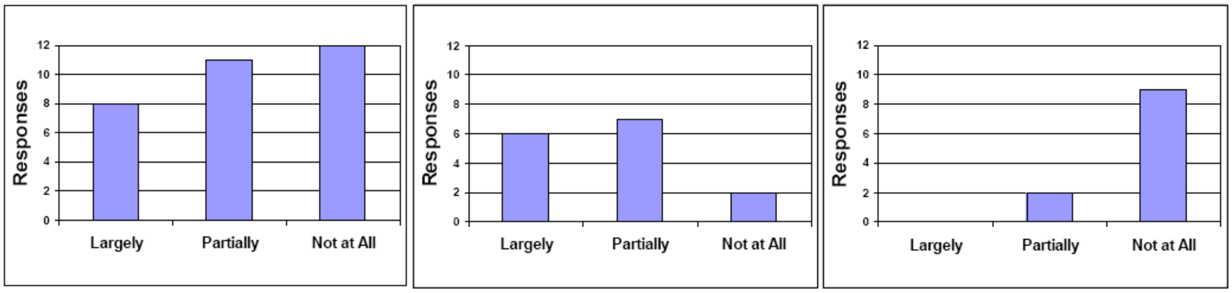
4.8. European Facilities Generally Pay User Expenses

Globally, the response from facilities to the question of whether facilities pay expenses largely, partially, or not all was a mixed response. As seen in Figure 4.4, 19 facilities pay expenses largely or partially, and 12 facilities pay none.

[Note: The original text says 11 facilities pay none, but the figure shows 12.]

However, when these responses are separated by region, we see that most facilities in Europe pay travel expenses, largely or partially, while most facilities in the United States do not. At the two large multinational facilities in Europe (ILL and ESRF) and at ISIS in the United Kingdom, the travel and accommodation expenses of users to conduct experiments at the facility are paid by the facilities. For multinational facilities, this applies to users from the participating nations.

The Europeans consulted as part of this study feel that paying travel expenses was most important in creating a large user community, especially for neutron scattering facilities, and that payment of travel expenses remains important in maintaining that large user community. In the United States, the payment of travel expenses does seem helpful for new users who may not yet have research support to conduct an experiment and who will have to fund it from other resources. This point is discussed further in Section 5.2.2.



WORLD WIDE EUROPE USA

Figure 4.4. Number of facilities that pay users' expenses to conduct experiments, largely, partially, or not at all.

4.9. Instruments Supported Through Participating Research Teams

To finance the construction and operation of beamlines and instruments, some facilities invite Participating Research Teams (PRTs) to construct and operate beamlines and instruments. A PRT is a consortium of users, often from a single institution, who form a team to raise the funds for and operate a particular beamline and/or instrument. In exchange for providing the financial support for the beamline or instrument, a fraction of the experimental time is dedicated to the PRT scientists.

Averaged across all the facilities responding to the questionnaire, in 2004/2005 about 20% of all beamlines and instruments were funded and operated by PRTs. The percentage ranges from as high as 100% (e.g., at ISSP) to 0% at a number of facilities. It is likely that the current percentage of PRT instruments at any given facility depends largely on historical factors and the philosophy used to build both the facility and the original instrument suite. The popularity of PRT-type funding to build instruments (or beamlines) has oscillated over the years.

Currently within the United States, the DOE is moving away from PRT-type support at some of their facilities, notably the APS. At the APS, it was found that to support a beamline effectively, the PRTs often consisted of a large consortium of institutions with diverse interests. This led to beamlines and instrumentation that were multipurpose, with natural compromises on optics to support a broad suite of instruments at a given beamline. As a result, there was much duplication of instrumentation across many beamlines. By moving away from PRT-type support, particularly those with broad instrument suites, and instead dedicating beamlines to particular classes of instruments, the goal was to create more specialized and higher performance instrumentation, support staff, and, ultimately, science. An additional problem with PRTs was that, from one PRT-supported beamline or instrument to another, there was little universality of construction. This situation made it difficult to transfer samples from one beamline or instrument to another.

The percentage of experimental time on a PRT instrument that is allocated to PRT scientists and to other users, via the proposal program, in 2004/5 was, on average:

48% for the PRT scientists group
44% for other users, via the proposal program
5% for others

This finding is interesting, because it indicates that about half of the instrument time is typically set aside for the funding group (i.e., the PRT) and about half is set aside for general users (typically through a user program). Within these averages, there are significant variations, from a low of 6% being allocated to the PRT-type groups at SSRL and the Beijing Synchrotron to a high of 100% being allocated to the PRT-type groups at St. Petersburg Nuclear Physics Institute and the Frank Lab for Neutron Physics. Also, the time allocation ratio can vary between different PRT instruments, depending on the details of the agreement reached between the sponsoring PRT and the facility.

4.10. Percentage of Beamtime Allocated to Facility Scientists

The responses to the questionnaire also provided insight into the percentage of beamtime that is allocated to facility scientists versus that allocated to user programs and PRTs. On average, the percentage of beamtime allocated to facility scientists is 15-20%. This percentage has remained constant over the past eight years (see average values in table below). There are, however, some ambiguities in the results, because some very active user facilities (e.g., NCNR and ISIS) do not formally allocate any time to facility scientists outside of the proposal system (as noted earlier in Section 4.5).

Year	Proposal or PRT	Facility Scientist
1998	65%	14%
1999	64%	19%
2004	66%	20%
2005	68%	19%

4.11. Proposal Review

Proposals for beamtime are first reviewed for scientific merit, with a recommendation for beamtime based on this review. Of the 23 facilities that responded to this question, all facilities--except two--have a single review process. All proposals, regardless of country of origin, are reviewed using this single review process.

The two exceptions were: Jülich (which has a special international panel set up by a European body which reviews foreign proposals) and ISSP Japan (which requires that a Japanese collaborator must submit the proposal). (In the latter case, this is probably determined by language and local knowledge issues and seems understandable.)

Among those facilities that had a single process, four of them (Elettra, SRS, ILL and Pohang Light Source) reported that a “reasonable percentage” is allocated to foreign users, i.e. users from countries or institutions that are not members of the facility.

Twenty facilities reported that they have foreign scientists on their proposal review committees. Of those that did not, three were US facilities (CHESS, NIST, and HFIR), one was a European multinational facility (ILL), and the rest were in Russia or Asia (St. Petersburg, Siberian Light Source, Pohang, Beijing, BSRF, ISSP, and SPring-8).

4.12. Award of Beamtime and Foreign Use of Facilities

Five facilities (ILL, ESRF, CNBC, LLB, and HFIR) reported that, following the review and recommendation for beamtime based on scientific merit, there are some adjustments and balancing of actual time allocated among the member countries and associates. At multinational facilities, the aim of adjustments is to bring the percentage of time allocated to scientists from member nations approximately in line with the percentage of funding contributed to the facility budget from member nations. In multinational facilities, the need to award beamtime to users from member nations in approximate proportion to the budget provided makes it difficult to allocate time to non-member nations beyond an agreed upon percentage.

Eight facilities (APS, Siberian Light Source, IPNS, FLNP, Lujan, SSRL, SRS, Dubna, and St. Petersburg) reported that there were no adjustments. (Note, however, that half of the surveyed facilities did not respond to this particular question.)

In the majority of the facilities (23 facilities, including the Hamburg Synchrotron, CHESS, SRS, BESSY, SINQ, SLS, Pohang, SSRL, Lujan-LANSCE, ALS, Jülich, LNLS, NIST, MAxLab, ESRF, APS, HMI, ILL, Spring-8, Elettra, LLB, HFIR, and CNBC), statistics are kept regarding the use of the facility by foreign (or non-consortium) scientists. The facilities that did not keep these statistics (with the exceptions of NSLS and IPNS in the United States) were in Russia, China, or Japan. In any case, the number of foreign users at this latter group of facilities is very small.

Access to foreign facilities can also be obtained by international collaboration. Indeed, the percentage of beamtime used by teams that have foreign nationals on them is reported to be large. In Europe, the results were: HASYLAB 50%, BESSY 50%, HMI 65%, SINQ 75%, SLS 75%, Jülich 43%, LNLS 15%, MAXLAB 70%, Elettra 52%, and LLB 38%. In North America, the results were: CNBC 40%, APS ~ 48%, SSRL 13%, HFIR 82%, and LANSCE 50%. In Asia, the results were Pohang 3% and SPring-8 5%. For those teams in which foreign nationals serve as spokespersons, team leaders, or primary investigators (PIs) on the proposals, the percentage of beamtime is somewhat lower. In Europe, the results were: BESSY 8%, HMI 50%, SINQ 45%, SLS 50%, Jülich 38%, LNLS 15%, MAXLAB 45%, Elettra 48%, LLB 27%, and SRS 2 %. In North America, the results were: CNBC 25%, SSRL 13%, HFIR 82%, and LANSCE 50%. In Asia, the results were: Pohang 3% and SPring-8 5%. Many facilities do not keep both statistics. ESRF and ILL did not report the percentage of foreign use, but access to each of these two facilities can be obtained by collaboration with a scientist from a member nation.

These numbers appear to show that use by foreign nationals is quite large at European facilities, where proximity among nations is a major asset. At US facilities, (e.g., at LANSCE, HFIR, and APS), most of the foreign nationals appear to be graduate students, post-doctoral associates, or other users from US institutions who are not US citizens. The percentage of users of US facilities who are from foreign institutions appears to be much smaller (e.g., 10 % at IPNS and 12 % at NIST). Thus, use of US facilities by foreign nationals from institutions abroad appears to be low. Use of Asian and Russian facilities by foreign nationals ranges from very low to non-existent.

The questionnaire asked for information about visa requirements at facilities, and the response was mixed. Twenty-two facilities said visas were required. Eight facilities (Siberian Light Source, St. Petersburg, Frank Laboratory of Nuclear Physics, Beijing Synchrotron Facility, Pohang, CHESS, ILL, and LNLS) said visas were not required.

It appears that national security issues have been an obstacle to some foreign participation, mainly at US facilities. The problem has been steadily increasing over the period from 2003 to 2005. National security issues were reported as the reasons for denying access in 2003/4/5 at the following facilities: SSRL (18) Lujan (17), ALS (9), APS (30), and HFIR (1). No other facilities reported such cases. Canadian Neutron Beam Centre requires local staff to accompany non-resident users to beamlines. HMI requires a security check for foreign users in non-guide hall areas. ESRF checks for “sensitive” countries.

4.13. No Trend Toward Multinational Facilities

Twenty-two facilities, including all those in the United States and Asia (with the exception of the Beijing Synchrotron Radiation Facility) and many in Europe, indicated that they did not see a future trend to multinational facilities. Of the nine facilities that said they thought there was such a trend, two facilities (ESRF, ILL) are already European multinational facilities, five facilities (Elettra, HMI, Hamburg Synchrotron, SRS, and BESSY) are in Europe, and one facility (BSRF) is in Asia. The data of this study and the list of future facilities in Appendix 3 indicates that, while current multinational facilities will remain the largest and most productive for the coming 10 years and new ones are planned, there is not a trend toward multinational facilities.

4.14. General Conclusions on Proposal Review and Foreign Use of Facilities

Based on the questionnaire responses, some general conclusions about proposal review and foreign use of facilities are:

- Access to all facilities, whether national or multinational, can be obtained by collaboration with a scientist who is from that nation or from a member nation of the multinational facility.
- All proposals at all facilities, with one or two minor exceptions, are reviewed for scientific merit within the same proposal review program. Once reviewed, proposals at ILL and ESRF that do not include a scientist from a member nation are generally limited to 10 % and 5 % of total beamtime, respectively.
- At national facilities, there is apparently no declared limit to proposals without a domestic partner. However, essentially all facilities keep track of foreign use of their facilities.
- Use of facilities by foreign scientists from institutions outside the nation is high in Europe, often 50%. Use of facilities by foreign scientists from institutions outside the nation is significantly lower in the United States. Use of facilities by foreign scientists from institutions outside the nation is rare (only a few percent) in Asia and Russia, but this is expected to change significantly in the next 5-10 years.
- National security issues have been an increasing barrier for foreign users at US facilities during the period of this study (2003-2006).

4.15. Limits to Access Arising from Limited Operating Budgets

Access to a facility can also be significantly limited by an inadequate annual operating budget at the facility. Without an adequate budget to operate for a full period of time, to support instrument scientists, to maintain the facility and to make some upgrades, a facility cannot realize the full potential of its beamlines and instruments. Signals of an inadequate budget are:

- the facility operates for a limited time period during the year.

- funds for new instruments and upgrades of current instruments are redirected to support existing instruments. This postpones improvements and can result in instruments not being scientifically competitive with facilities elsewhere in the world.
- support for instrument scientists, e.g. hiring new or replacement instrument scientists, is reduced. This results in reduced operating time for some instruments or the instrument being completely removed from the user program.

Some of the major US facilities indicated that operating budgets are a major concern. They provided input on the opportunity cost of inadequate funding. For example, the NIST Center for Neutron Research estimates that their general user program is operating only at about 81% of current capacity. The APS has had to curtail operating hours from about 5000 hours to 4448 hours in fiscal year 2008 (an 11% decrease). The APS estimates the maximum number of operating hours per year is approximately 5500-5600, but this requires sufficient staffing to complete accelerator maintenance and improvements in the decreased downtime brought about by increased operations. The Lujan Neutron Scattering Center estimates that their operating time is at about 86% of the capacity for beamtime and operates at an overall capacity of about 60% of maximum for the facility.

Fully funding existing facilities so that they can operate to full beamtime capacity and upgrading and replacing instruments at the facilities is an effective and efficient method of enlarging access.

SECTION 5: RESPONSES TO QUESTIONNAIRE TO USER GROUPS AND SOCIETIES

5.1. Introduction and Purpose of the Questionnaire

Most synchrotron X-ray and neutron scattering user groups and societies were formed about 15-20 years ago. They were created to address both the needs of the science and engineering user community and the needs of the facilities themselves. In the early days of neutron scattering, at least in the United States, most scientists using neutrons were employed in the same national laboratories that housed the neutron facilities. Over time, as the value of neutron scattering became evident, scientists outside the national laboratories began to use neutrons in their research. Synchrotron X-ray scattering is relatively more recent, and, from the beginning, many of the users came from outside the national laboratories. While the user groups generally represent the users of a specific facility, the societies represent all users of the technique and are generally not connected to a particular facility. The reason various user groups and societies (UG/Ss) were established can be readily understood in terms of the nature of the community they represent.

Firstly, the community that uses synchrotron X-ray and neutron facilities is scientifically very diverse. Members come from the fields of physics, chemistry, biology, materials science, engineering, and a wide spectrum of related sciences. There is no single discipline-related organization that can represent this community. This is in contrast to the nuclear and particle physics community, for example, which has a division within the American Physical Society that can represent the field and its need for major facilities.

The synchrotron X-ray and neutron scattering community is also institutionally and geographically diverse. The members come from national laboratories (some of which have facilities themselves), from universities, from corporate laboratories, from hospitals, and from other institutions across the nation.

In addition, the typical scientist or engineer uses a given facility only a modest amount per year (often 10 days or less). Generally the users, who include scientists and their postdoctoral associates and students, do not stay for long periods at the facility working on a single experiment as is often found in particle physics. Because of this, many users do not have close connections with the facility (or facilities) and may understand little about how or under what constraints the facility operates. Particularly, for many users, synchrotron X-ray and neutron scattering is one tool among several that they use to pursue their science and investigate their samples.

The need for access and for establishing attractive terms of access is a clear motivation for the existence of both user groups and societies.

This is particularly clear for a user group associated with a specific facility. The membership elects an executive (or executive committee) who represents the users in discussions with the facility management. The discussions generally concern access and terms of access. The level of activity of the user group often varies with time, depending on the stage of development and upgrade status of the facility. For example, the IPNS User Group was large, and it was very active during the development of the Intense Pulsed Neutron Source at Argonne National Laboratory. The societies serve a similar function as user groups, but societies are generally organized nationally and are concerned with issues that affect all the facilities across the nation. The societies also hold scientific meetings and workshops and more broadly represent the interests of all users.

In the United States at least, the user groups and societies are seen as more important and have played a larger role in the neutron scattering community than in the synchrotron X-ray scattering community. This is probably because the availability of neutron sources and instruments has been more limited than the availability of synchrotron X-ray sources and beamlines in recent years. (See Section 3.3 and Section 4.3 comparing the number of neutron scattering instruments in the United States and Europe.)

UG/Ss can improve access in several ways. First, the existence of the user groups and societies demonstrates clearly to government and funding agencies that there is a scientific community requiring access to facilities. The societies can also make the case, on behalf of the community, for the funding of new facilities and upgrades to existing facilities. The societies play an important role in setting out the scientific opportunities that will be created and enabled by the facilities. The societies can play a critical role here because the range of science is so diverse; a coordinating society is critical in having access to the full range of users. The case can also be made in this way independently of the facilities themselves. A compelling scientific and engineering case coming directly from the community with demonstrated numbers of users and a united view can be most effective in assisting funding agencies to secure financial support for facilities. In addition, the UG/Ss can provide community guidance for establishing new scientific capabilities and advice on making the case for expansion of the facility.

The UG/Ss also provide a forum for exchange of information and ideas among users, between users and facilities, and on access to these facilities. They can provide feedback from the community to the facility on user needs and access issues. In this way, UG/Ss can significantly improve accessibility by providing information to users and feedback to the facility on allocation of resources. National-level societies also generally organize scientific meetings that provide a forum to communicate the science and engineering done at facilities. These meeting are usually organized in collaboration with a particular facility. The meeting usually includes sessions on new instruments and capabilities that are planned at the participating facilities, as well as sessions on access issues. The

UG/Ss hold schools and workshops (especially in Europe) to introduce new users to the techniques and to promote the field broadly.

To evaluate some of these ideas, we sent a questionnaire to the executives of a broad range of UG/Ss. The questionnaire included two parts:

- Part A addresses the role of the user groups and societies. What are the most important functions of the UG/Ss as seen by the executives of the UG/Ss?
- Part B addresses access issues. What are the characteristics of an outstanding and accessible facility as seen by the UG/Ss?

5.2. Responses to the Questionnaire

Of the 17 responses to the questionnaire, 7 were (self-) classified as societies and 10 were user groups (Appendix 6 lists the responding user groups and societies). Societies can be organized at the national level, such as the Swiss Neutron Society, or at the regional level, such as the European Neutron Scattering Society.

As a general rule of thumb, *User Groups* are affiliated directly with a particular synchrotron X-ray or neutron source and represent the users of the source. For example, APSUO (the APS User Organization) represents the users of the Advanced Photon Source at Argonne National Lab. Most of the major synchrotron X-ray and neutron facilities throughout the world have user groups associated with them, though the level of activity of these groups varies widely from source to source.

A *Society* is generally an independent organization that represents users of a scientific technique or field and is often organized and draws its membership at the national or international level. For example, NSSA (the Neutron Scattering Society of America) represents users of all the neutron sources in the United States. The distinction between user groups and societies is relatively clear in the United States. In other countries, however, the distinction is not always clear, with the role of a user group overlapping with that of a society. This is often the case where there is a single main synchrotron X-ray and/or neutron source, and most of the functions can be accomplished by a single organization.

The sum of the membership data reported by all the responding organizations is approximately 20,000, but this undoubtedly involves a significant amount of double counting, as many scientists are users at multiple synchrotron X-ray and neutron facilities. Part A of the questionnaire asks the executive of a user group or society to identify its most important goals and activities. Part B asks the executive to rank features of a facility as most important or less important.

5.2.1. Goals and Activities of User Groups and Societies

The questions posed in Part A are reproduced below.

> PART A) GOALS AND ACTIVITIES OF YOUR USER GROUP/SOCIETY (Questionnaire)
>
> Please Rank from 4 to 1 (4 being the top score) the importance of the following goals and activities to your group/society:
>
> 1. Provides a feedback mechanism from users to the facility or facilities
> 2. Holds regular meetings of your members
> 3. Actively lobbies on behalf of facilities and/or science
> 4. Oversees proposal/experiment time allocation
> 5. Reviews/provides oversight of facility

From the responses, displayed below in Fig. 5.1, it is clear that the executives of the user groups and societies see their most important role as *providing a feedback mechanism from users to the facility or facilities.* A user group is specifically the liaison between individual users and facilities. This response is entirely consistent with the general view of these groups from both the users and the facilities.

The second most important role is to *actively lobby on behalf of facilities and/or science*. The responses to this question are comparable to question 1. As discussed in the Introduction, this was one of the motivating reasons for creating societies. Within the US community, there has been a growing realization in both the user groups and the societies that lobbying is of increasing importance in the current era of difficult funding and tight budgets.

Active user groups *hold regular meetings of your members*. These meetings are generally held at or near the facility associated with the user group. Some user groups (and the associated facility) are more proactive than others about organizing and holding these meetings. Although seen as important, the responses in Fig 5.1 show that meetings are not a defining role. For the societies, regular meetings are also important, though these meetings focus more on the science and less on the user issues than do the local user group meetings. For example, both the European Neutron Scattering Association (ENSA) and the NSSA run regular large scientific meetings (typically every two or three years) which are attended by both national and international scientists. The societies, such as ENSA and NSSA, are also involved with international conferences, particularly when the conference is hosted in their home country. For example, the Australian Neutron Beam Users Group (ANBUG) was involved in organizing the 2005 International Conference on Neutron Scattering when it was held in Sydney.

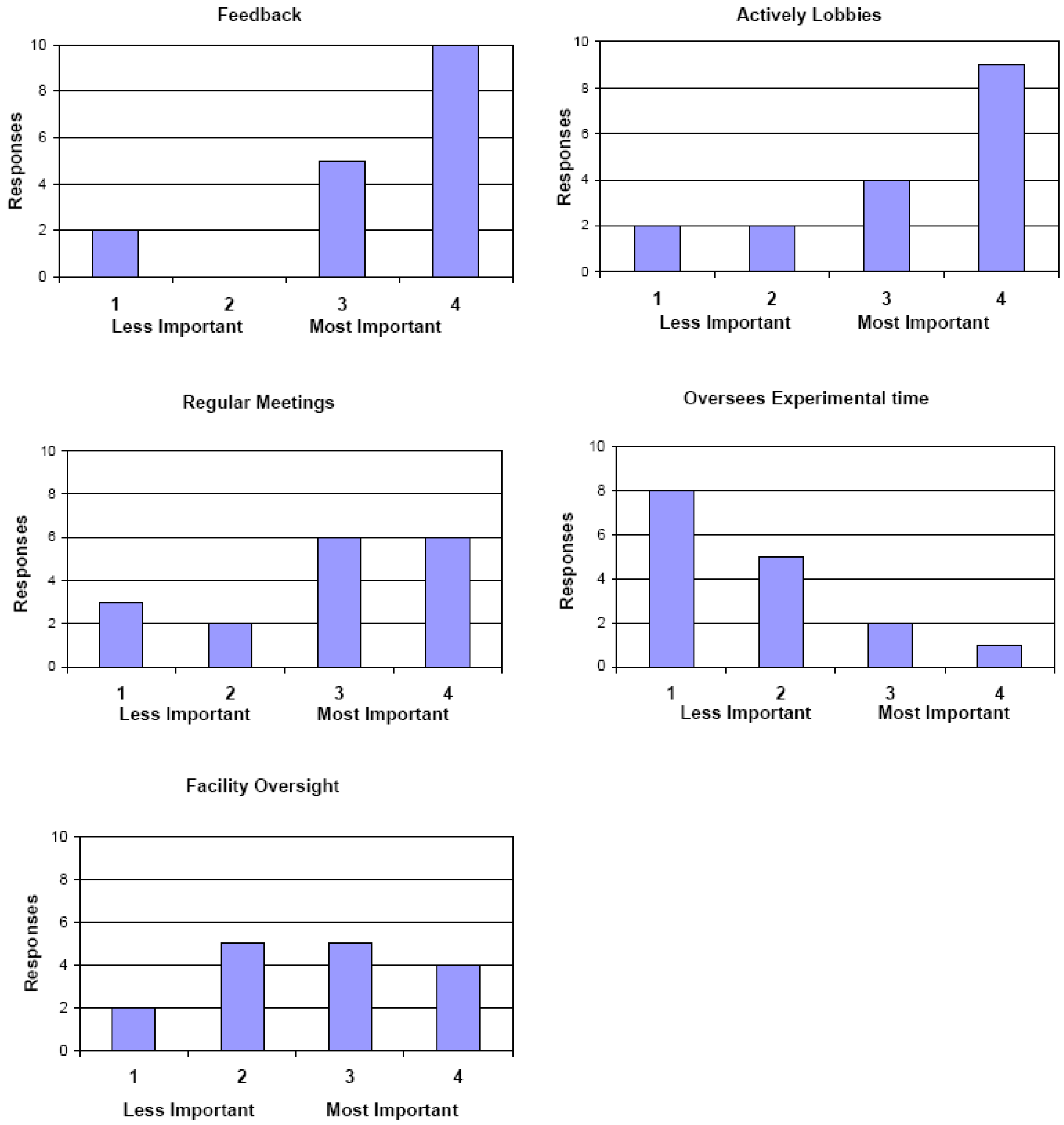


Figure 5.1 Most important functions of user groups and societies as reported by the executive of the UG/S.

Fig. 5.1 shows that *overseeing proposal/experiment time allocation* is not seen as an important activity by most UG/Ss. Usually, review of proposals for beamtime and oversight of allocation of beamtime is done within a separate proposal review system as described in Section 3.1. Most facilities do not ask their associated user groups for proposal review or oversight on beamtime allocation. However, individual users are asked to sit on the proposal review committees and committees that provide oversight. The responses to this question are consistent with this picture.

The question on whether a UG/S *reviews or provides oversight of a facility* drew a mixed response. In the United States, facilities generally draw upon the membership of their associated user group and prominent scientists from the national/international community to form committees tasked with oversight and review. They do not ask UG/Ss directly for this review. Outside of the United States, a number of societies are involved directly in review and responded to this question with a 4. For example, the Canadian Institute for Neutron Scattering (CINS) is directly involved with the oversight of the Canadian Neutron Beam Centre in Chalk River. The responses to this question (below) are consistent with this picture of a varied role of UG/Ss.

5.2.2. Features of a Facility Most Important to Users

The questions posed in Part B are reproduced below.

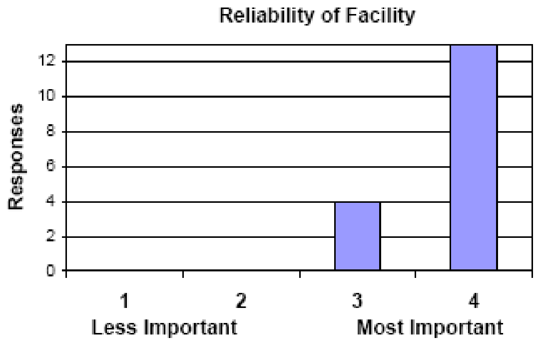
> Part B) PRACTICES OF USER FACILITIES (Questionnaire)
>
> Please Rank from 4 to 1 (4 being the top score) the importance of the following features at a high quality user facility from the viewpoint of the group you represent:
>
> 1. Uniqueness of facility, source details and/or specific instruments
> 2. Reliability of facility operation
> 3. Availability of sample environment equipment
> 4. Good technical personnel and lab support available at the facility
> 5. Reasonable success rate of submitted proposals
> 6. Regular, well publicized call for proposals
> 7. Accurate and complete information on access to the facility
> 8. Equitable proposal review process with external reviewers
> 9. Ease of travel to site
> 10. Good accommodations on site for housing/food

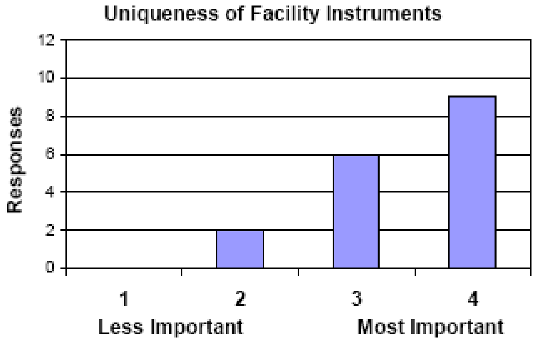
Part B of the questionnaire asked UG/Ss to rank specific features of a facility in order of importance, features that make it an attractive and sought-after facility. The histograms below display the scores of these features from 4 (most important) to 1 (least important) as seen by the users. The features are presented in order of their importance perceived by users.

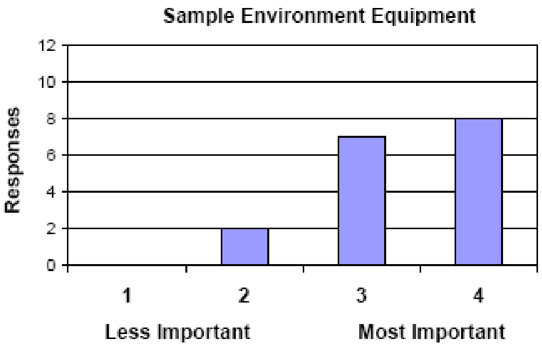
Reliability of facility operation was identified the number one issue in the list of 10 items. It received scores of chiefly 4 and some 3s (see Fig. 5.2 below). Reliability is directly related to the ability of users to get their experiments done. The ranking of reliability was the same in Europe and the USA. Almost all experienced users have had beamtime allocations lost because of this issue and know the difficulty it can cause with student theses, lost samples, delays, and incomplete data.

Ranked second in importance, with comparable scores, were *1. Uniqueness of facility, source details and/or specific instruments; 3. Availability of sample environmental equipment;* and *4. Good technical personnel and lab support at the facility* (see also Fig. 5.2). The uniqueness of the facility addresses why a user selects a particular facility, as does in part the availability of sample environment equipment. Specifically, a facility with unique instruments or beamlines or specialized sample environment facilities provides a unique resource enabling new and innovative science. Items 3 and 4 address this aspect and the ability to complete an experiment. High performance on all of these items is a characteristic of a top user facility.

Next is a group of issues dealing directly with obtaining beamtime: *6. Regular, well publicized calls for proposals; 8. Equitable proposal review process with external reviewers;* and *7. Accurate and complete information on access to the facility*. (See Fig. 5.3 below). These issues regularly come up at user meetings as they provide the gateway to the facility, particularly for new users who don't have any ongoing collaborative interactions with facility scientists. From the point of view of running a user facility, the importance of items 7 and 8 for new users cannot be overstated. Items 6 and 7 may be labeled as administrative issues, but they are seen as important components in open and fair competition for beamtime.


Reliability of Facility


Uniqueness of Facility Instruments


Sample Environment Equipment

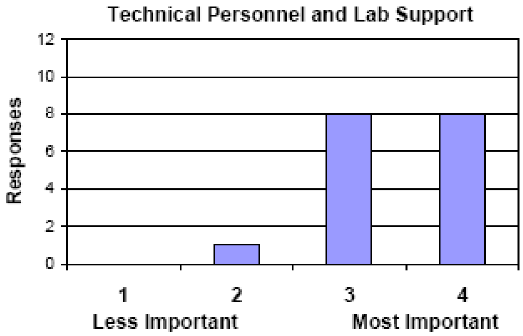

Technical Personnel and Lab Support

Figure 5.2 Characteristics of a facility that are important to users as reported by the executive of user groups and societies.

It is interesting to note that a *Reasonable success rate of proposals* (Item 5) was the lowest-rated issue involving obtaining beamtime. Most likely this is because users generally considered writing a successful proposal to be the responsibility of the individual scientist. It is their responsibility to propose high-quality work. Most scientists are willing to accept the results of a negative review if the review process itself is considered to be fair and equitable.

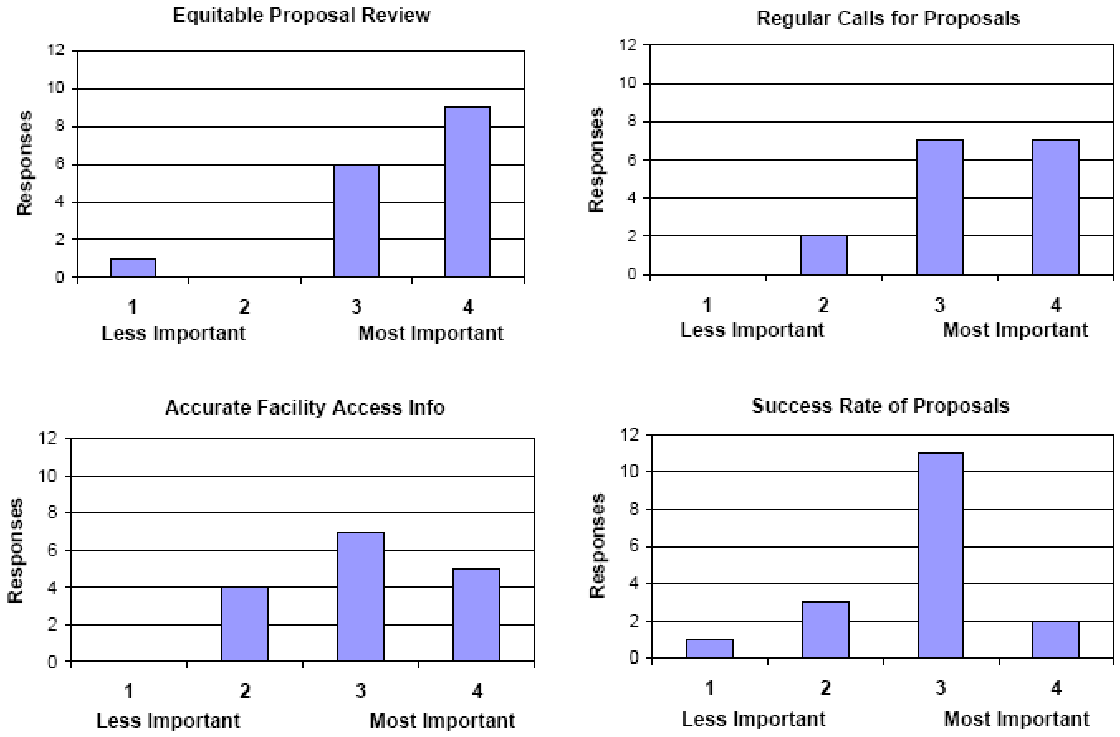


Figure 5.3 Characteristics of a facility that are important to users as reported by the executive of user groups and societies.

The last two items--*10. Good accommodations on site for housing/food* and *9. Ease of travel to site*--were seen as important but ranked low in priority (see Fig. 5.4). Clearly, the priority is on innovative and successful science at the facility and on fair access to the facility. The latter two items are important to the overall user experience. Also, with the increase in security issues at all federal facilities, clear information on access and the clearance process is critically important for university users (in particular) where many of the graduate students are foreign nationals. Also, convenient housing and food are part of the overall support system that builds a top-level user facility.

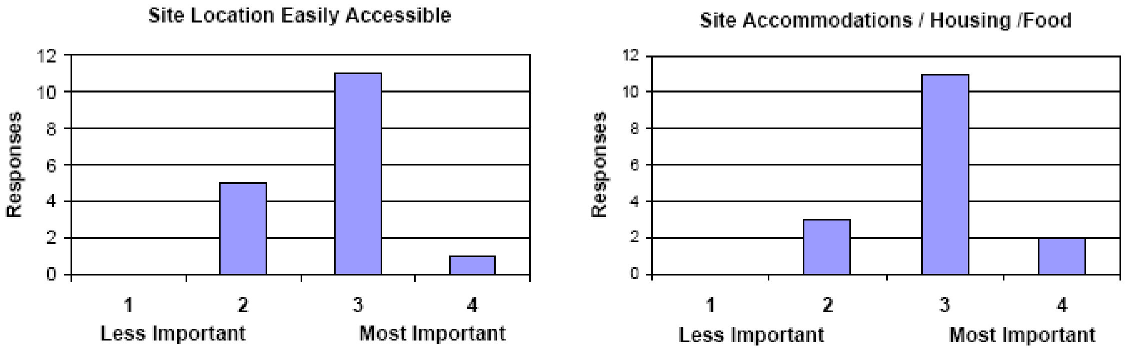


Figure 5.4 Characteristics of a facility that are important to users as reported by the executive of user groups and societies.

SECTION 6. TERMS, CONDITIONS, AND FUTURE OF ACCESS

This section discusses, based on the questionnaires and interviews of this study, the terms of access and the conditions that promote access to major facilities abroad. Many issues are common both to use of facilities abroad and to use of national facilities within a specific nation. The findings are presented from the perspective of users. The findings apply particularly to users who reside in the United States, but many aspects will apply globally.

Section 6.1 discusses access policies. Section 6.1.1, under “nation-to-nation” access policies to national facilities, considers the policies for access to national facilities in one nation by scientists from another nation. Section 6.1.2 discusses access policies of multinational facilities--facilities such as ILL and ESRF that are funded by a group of nations. Section 6.1.3 discusses access to US facilities by scientists resident in the United States

Section 6.2 reviews why scientists seek access to facilities abroad; why ready access promotes productivity in science and engineering; and why, from a user’s perspective, ready access should be encouraged. Specific mechanisms of obtaining and encouraging access to facilities abroad are identified in Section 6.3. Factors that are barriers to access or limit access are identified in Section 6.4. Section 6.5 concludes by discussing how the availability of facilities is evolving in the world; how the user community is evolving; how the nature of experiments at facilities is evolving; and how these changes will affect the meaning of access for users.

6.1 Basic Access Policies

6.1.1 Nation-to-nation access policies

Access to facilities is obtained by submitting a proposal to conduct an experiment. A nation-to-nation access policy is a policy which enables scientists from one nation to submit proposals to facilities in another nation and the proposal will be awarded experimental time on scientific merit independent of national origin of the proposal. There is no formal written policy or agreement at a funding agent (e.g., DOE or NSF) or facility level on this nation-to-nation access policy. Most national facilities responding to the questionnaire endorse this policy (with the important caveats discussed below). At the same time, national facilities clearly monitor foreign use of their facility, and, following review for scientific merit, these facilities may award time taking account of the origin of the proposal. This is consistent with the findings of the OECD Megascience Forum Working Group, which was based on a survey of funding agencies of 12 OECD nations in 1998. There appears to be a general understanding of this policy among nations, facilities, and members of the scientific community, and this policy has not changed for at least 10 years.

National facilities are facilities built and operated by a single nation. Specifically, the nation-to-nation access policy is adopted by the United States and its synchrotron X-ray and neutron scattering facilities, which are all national facilities. Within the nation-to-nation policy is the implicit understanding of reciprocal use of national facilities. That is, access to US facilities is open to all on the basis of scientific merit, and, reciprocally, foreign facilities are anticipated to be open to US scientists on the same basis.

This nation-to-nation access policy, by and large, functions well between national facilities. If adopted unreservedly, it would mean that the national facilities of the world form a global facility network that is free and open to all scientists. This is, of course< not the case. National facilities are constructed in a given nation, even in the region of a specific nation, to meet national goals or political realities. The facilities represent a national and often a local (e.g. state) investment. There is an expectation that they will be used primarily by nationals. If use by foreign scientists exceeds a certain percentage of facility time or is seen to crowd out national users, political or other pressures may arise. Equally and quite frankly, if proposals to do similar science are received simultaneously from foreign and national research teams and the teams are in apparent scientific competition, the national team will be favored. It is difficult to maintain a scientific program at a foreign facility if there is a competing group in that nation. Scientists generally understand the issues of balance and the unstated guidelines of nation-to-nation access.

Most of the 32 facilities responding to the questionnaire (see Section 4) keep statistics on foreign use of their facility so that the degree of foreign use is known. In Europe, the percentage of beamtime used by teams that have foreign nationals is high (e.g., 75 % at SINQ and SLS in Switzerland, 50 % at HASLAB and BESSY and 65 % at HMI in Germany, 38 % at LLB in France, and 15 % at LNLS in Spain). Reciprocally, the Swiss use a wide range of facilities in Europe.

The percentage of beamtime used by teams that have foreign nationals is also high in the United States (e.g., 82 % at HFIR, 50 % at the Lujan facility, and 48 % at the APS). However, most of the foreign nationals using US facilities are graduate students at US universities who reside in the United States. For example, teams including foreign scientists from foreign institutions use a much smaller percentage where this is tracked (e.g., 12 % of beamtime at NIST and ALS and 10 % at IPNS). Foreign use of facilities is currently smaller in Asia (e.g., 3 % at Pohang). Japanese facilities require a Japanese team member, a policy that probably makes excellent sense in Japan. Generally, foreign use of facilities is greater in Europe than in the United States, probably for geographic reasons.

The policy of reciprocal use of national facilities between individual nations works best if there is an approximate balance of availability of facilities between the two nations. There can be an imbalance of availability for a period of time. However, if this period is too long (i.e., too many years) and there are no clear signs of a coming correction, there can be political strain. There can also be difficulty if the imbalance is quite significant and apparent. The policy operates chiefly between larger nations that have large scientific communities and advanced major facilities. It is particularly a policy that operates between the United States, the larger European nations, and Japan. China will clearly be a major participant in the near future. Scientists from smaller nations usually are accommodated in collaborations whether or not the smaller nation has advanced facilities or not. As noted below in Section 6.3, collaboration with scientists of the host country always affords access to foreign facilities.

The policy of reciprocal use of national facilities between individual nations works well for experienced users but less well for new or less experienced users. Essentially, the experienced user attends scientific meetings on synchrotron X-ray or neutron scattering often held at or near facilities. He or she visits facilities and knows people there and may have done experiments previously at the facility or at similar facilities. The experienced user has contacts at the facility or knows people who do have contacts. Experience with proposal submission and selection criterion is a great advantage. In contrast, it is often difficult for a new user to get started, to make the initial contacts, to establish a collaboration, and to identify the keys to successful proposal writing. Also, as the fraction of the user community who are occasional users grows, the desire to use foreign facilities at some distance may diminish.

6.1.2. Multinational facilities (ESRF, ILL, Frank Laboratory (Dubna))

The access policy of multinational facilities may be most readily explained using the specific examples of the European Synchrotron Research facility (ESRF) and of the Institut Laue Langevin (ILL).

ESRF is a *société civile* (a company) under French law. The company owns and operates ESRF. There are eighteen member nations of the company, that each provide a well-defined percentage of the ESRF annual budget (see web site for percentages). The ESRF also has six scientific associates. The scientific associates are non-member nations or institutes that agree to pay a fixed percentage of the annual budget of ESRF. Scientists from the member nations and from the associates are invited to submit proposals for experiments at ESRF. The proposals are awarded beamtime by external scientific review committees, based on scientific merit (see Section 4 on questionnaire to facilities).

Scientists from non-member countries can obtain access by:

1. Collaborating with a scientist resident in a member country
2. Their institute or government becoming a scientific associate
3. Submitting a proposal that is of exceptional merit and is awarded time under the management’s contingency (typically 5 % of scheduled time)

Some 25 % of ESRF beamlines are funded and managed by Collaborating Research Groups (CRGs). These groups obtain two-thirds of the beamtime on these beamlines, with one-third of the time awarded to other users in the general proposal/review program.

ILL is also a *société civile*. ILL began in 1967 as a joint French-German project, with the United Kingdom joining soon after (see Section 3.3). It is directed by the three founding members in association with ten scientific associates that joined subsequently and provide 14 % of the annual budget. The access criteria are the same as at ESRF except that 10 % is devoted to proposals of exceptional scientific merit from scientists from non-member countries. There are 42 instruments within the general proposal and external review program, and there are approximately 10 instruments funded and managed by Collaborating Research Groups (CRGs). As at ESRF, one-third of CRG beamtime is allocated generally via proposal and review. At ILL, the institution operating a CRG-managed instrument also operates the proposal review program for that instrument.

The travel and living expenses during experiments of the users from member nations and associates are paid by ESRF and ILL.

The Frank Laboratory at Dubna originated as a Soviet Union multinational facility. Post-USSR, it is a multinational facility with Russia and Eastern European nations as members. The various relationships are defined in several associated international agreements."

The nation-to-nation reciprocal-use policy is not compatible with nor does it apply well to multinational facilities (e.g. ILL and ESRF), which have a very different structure. For example, nations that are members of a multinational facility (MNF) cannot simply enter into an implicit or explicit nation-to-nation agreement with a non-member nation that includes the MNF. Similarly, the MNF itself cannot simply enter into nation-to-nation agreements. Multinational facilities report to many member countries and cannot independently establish an informal reciprocal use agreement with a non-member country without consent of members. The mismatch between a nation-to-nation policy and access policies of multinational facilities needs to be appreciated and understood in the United States as a mismatch

6.1.3 National facilities within the United States and US users

All synchrotron X-ray and neutron facilities in the United States are national facilities. There is typically a call for proposals every six months. The proposals are reviewed by external review committees (or by individuals from outside the facility) that establish scientific merit and feasibility. A proposal from outside the United States is generally reviewed and considered on the same basis. If the foreign team contains one or two scientists residing and/or working in the United

States, it is generally regarded as a US proposal. With the caveats noted in Section 3.1.1, particularly with regard to percentage use by foreign scientists, proposals are awarded beamtime based on scientific merit.

The travel and living expenses of users of US synchrotron X-ray and neutron scattering facilities are rarely paid for by US facilities (except for students in exceptional cases). In contrast, the travel and living expenses of users from member or associated countries at facilities in Europe, such as ISIS, ILL and ESRF, are paid by the facilities. When user programs were established in Europe in the early 1970s, payment of travel and living expenses was seen as a critical factor in building a user community (see Section 3). This payment certainly makes it easier for new users to get started, users who may not yet have grant support to use the facilities. A survey of members of the Neutron Scattering Society of America on this point was conducted by NSSA in 1993. The survey question was that, if the DOE had some additional operating funds, would you prefer to see the additional funds used to extend existing facility operating time or used to pay user travel and living expenses. Extension of operating time was preferred.

However, this survey was taken at a time when the availability of neutron beamtime was particularly scarce in the United States. Also, it is not clear what users of synchrotron X-rays would prefer and what users of neutrons would now prefer. Certainly, the travel and living expenses of students and postdoctoral associates in groups that have significant programs at facilities consume a significant fraction of group grant funds.

It should be noted that the EEC has a special fund (in addition to the travel funds provided by the facilities themselves) to which any citizen of a European country may apply, specifically for support of travel, living, and other expenses involved in use of major European facilities.

6.2. Reasons for Seeking Access to International Facilities

One reason for seeking access to an international facility is a general inability to get access to a particular type of instrument at a national facility, due to heavy oversubscription. The number of premium instruments available plays a crucial role in this regard. Experience with facilities has shown that once the oversubscription rate for a particular instrument rises above a factor of three or so, potential users are deterred from submitting proposals for that instrument. In the case of neutron scattering facilities, the total number of instruments in the United States lags far behind those in Europe. At ILL and ISIS alone there are currently more instruments than at all US neutron facilities combined (including the 24 planned for the SNS). It is also a statistical fact that the number of instruments drives the number of papers arising from experiments at a facility and that this number is strongly correlated with the scientific impact of that facility (see Section 4).

Other users may seek access to facilities in another country because of established or opportunities for scientific collaboration with scientists from that country. Apart from the returns of cooperation in science, these collaborations may be driven by (a) unique scientific instruments or sample environments not available in the United States or (b) specialty scientific programs not pursued in the United States. Similarly, US users interested in doing particular types of experiments on particular systems may find that the combination of instruments, beam intensities, sample environments, or data analysis software is optimized for those experiments at a facility in Europe or elsewhere. Until a few years ago, this used to be the case for neutron spin echo (NSE) instruments for ultra high-resolution inelastic neutron scattering experiments available at the ILL in Grenoble and other reactor facilities in Europe but not available in the US. (Currently, a NSE spectrometer is operational at the NCNR facility at NIST and one is under construction at SNS. The latter is an example of US-German collaboration and will be unique in the sense that it will be the first spin-echo spectrometer based on a pulsed neutron source, requiring a new design which will undoubtedly in turn be duplicated at other spallation sources in Europe and Japan).

Other examples of instruments that are currently more highly developed at European facilities, compared with those in the United States, are a variety of inelastic neutron scattering spectrometers with high intensity and good energy resolution. Figure 10 of the OSTP 2002 Report notes that there are four times more inelastic neutron scattering spectrometers in the Europe than in the United States. As a result, for example, the study of the dynamics of proteins, macromolecules, and water in these environments (as opposed to structural studies) is a field that is highly developed in Europe, but largely unvisited in the United States. Also, there are currently low-temperature facilities at ILL, ISIS, and HMI that don't exist anywhere at US facilities (e.g., the combination of a multi-detector time of flight inelastic neutron scattering spectrometer together with a dilution refrigerator and high magnetic fields on the sample). Other examples are:

- High-intensity instruments capable of either very high energy or momentum transfer, such as are found at ISIS in the UK or at ILL in Grenoble. This situation will also change with the full development of instrumentation at the SNS at ORNL)
- The so-called “cryopad” three-dimensional neutron polarization diffractometers for obtaining the complete vector magnetization density in samples available in Europe and Japan but not in the United States,
- A soft x-ray resonant magnetic scattering beamline which exists at the ESRF but has yet to be built at a US synchrotron X-ray facility.

Currently, the most efficient way for a US user to obtain access to these is to find a collaborator or a Participating Research Team or PRT (also known, in Europe, as a Collaborating Research Group or CRG) from a country that has access to these instruments. This type of collaboration is also likely to lead to a transfer of these technologies back to US facilities. Thus it is likely that, eventually, if the need is great enough, similar capabilities will eventually be available at US facilities. Another possibility, which appears to this panel to be highly desirable, would be for a US user group with significant need for such capabilities to partner with a foreign facility to develop such capabilities at that facility. (See section on “Access via bilateral agreements or instrument building” below.)

6.3 Means of Obtaining Access

6.3.1 Scientific collaborations

Access to foreign facilities can be readily and immediately obtained by collaborating with a scientist from that nation. This is particularly true for multinational facilities where access might otherwise be in question. If a proposal for beamtime at a MNF is submitted jointly with a scientist from a member country of the MNF, the proposal is immediately classified as a proposal from the member country. The collaborator could be an instrument scientist, someone else at the facility, or a scientist from any institution in the member country.

Collaborations have many other advantages. Often the collaborator, especially one from the facility itself, will know more about the facility. They will be more familiar with the criterion for a successful proposal, with who is on the review committees, and with the availability and level of competition for beamtime on different instruments. They will probably know what level of technical support is available at the facility and the availability of sample environment equipment needed for the specific experiment (i.e., what must be brought, what is already there, and how good it is). Especially for relatively new users, collaborations are an enormous advantage and greatly increase the likelihood of success in the experiment.

Collaborations are highly recommended as a route to access and excellence in science.

6.3.2 Participating Research Teams and Collaborating Access Teams

Access to a major facility can be obtained by establishing a Participating Research Team (PRT). PRTs are also denoted Collaborating access Teams (CATs) and PRT includes CATs. This method has particularly been used by US research teams to gain extended access to synchrotron X-ray facilities in the United States.

A PRT consists of a group of users who provide the resources to build and operate a beamline or instrument at a facility. In return, the members of the PRT have exclusive access to the instrument for a specified percentage of the available beamtime (varying from 40 % to 80 %) for a given period (e.g., five years from the commissioning of the beamline) or for an indefinite period. The beamtime at the disposal of the PRT is usually allocated among members by an internal committee of the PRT, based on proposals received from PRT members and their collaborators or, in some cases, even outside users.

PRTs, although not given this name, were used starting in 1973 at the Stanford Synchrotron Radiation Project (SSRP), and perhaps earlier at the 240 MeV Tantalus facility at the University of Wisconsin. The funds provided by NSF to start SSRP covered only the building to house the first beam line and parts of the beam line (front end, safety systems, diagnostics, etc.) but only a small part of the cost of the 5 experimental stations that were implemented on the first bending magnet line. Design and construction of these 5 stations were provided by 5 PRTs, made up of teams from Universities, Governmental and Industrial Laboratories.

In return for the contributions by these groups to design and largely fund the five end station instruments, and then commission them, each group was given priority use of the instrument for a specific period of time. As the first multi-GeV storage ring to be used as a synchrotron radiation source, even within the limits of parasitic operation on the high energy physics program, SSRP opened up a broad spectral range extending to hard x-rays. The development of the user community in the form of these outside teams helped to fuel the immense growth in synchrotron radiation research which continues to this day.

A similar but more extensive scheme with more formal arrangements (where PRT's were formally given that particular name) was developed at the NSLS in the early 1980s, when it was used partly to encourage industrial laboratories to invest in the facility and partly to find alternative sources of funding for instrumentation for the facility. It was widely used when the APS became operational (the consortia running the beamlines were known there as Collaborative Access Teams (CATs)). The PRT concept has also been employed at NIST, where certain instruments were developed with the majority of funding coming from an industrial laboratory, and the concept is also planned for the upcoming Spallation Neutron Source (SNS) in the form of Instrument Development Teams (IDTs).

The PRT concept is also in use at overseas facilities (e.g. ESRF) in the form of Collaborating Research Groups or CRGs (usually developed by scientists of a particular European country) who have developed some of the Bending Magnet beamlines and control two-thirds of the beamtime on those beamlines. In certain facilities, access to certain instruments is primarily controlled by groups representing the funding agencies that provided the resources to build the instrument (e.g., the NSF in the case of NIST, or the JAEA or KEK agencies in Japan in the case of the JRR-3 reactor and the upcoming J-PARC spallation neutron source.)

The PRT system in the United States in the last several years has experienced some difficulties. There appear to be several reasons for this:

1. Industrial laboratories have decreased their investment in beamlines at synchrotron X-ray sources (with the notable exception of pharmaceutical companies that use synchrotron X-rays for proton crystallography and drug design)
2. Many consortia of university users have found it difficult to find the resources to adequately staff and maintain their beamlines and instrumentation in a professional manner
3. Many PRT beamlines were built to satisfy researchers from one or more organizations who had a variety of research interests, ranging from small angle scattering and reflectivity to diffraction, inelastic scattering, EXAFS, imaging, etc. While this made for flexibility and in some cases enabled novel experiments to be done which could not be done at a standard beamline configured for "production", often much of the beam time was used for switching over from one kind of configuration to another, which made for inefficiency.
4. The PRTs often lack uniformity of sample holders, sample configuration, and sample environment equipment. This makes use of PRT beamlines by the general user difficult and greatly reduces the possibility of using common equipment throughout the facility.

In response to these difficulties and in the interests of greater efficiency, there has been a recent trend at US synchrotron X-ray facilities, supported by the DOE, to phase out some PRT instruments and convert them to 100% user instruments maintained and run by the facility staff. The PRT system at US synchrotron X-ray facilities has evolved to being concentrated on specialized instruments built to carry out experiments of a particular type (e.g., inelastic X-ray scattering, protein crystallography or imaging) that are 1) operated by the facility staff and 2) constructed by facility staff, working with a group of users distributed across various institutions who have a particular interest in those types of experiments with funds raised by the PRT. Protein crystallography beamlines, in particular, being funded by industry, foundations, or the NIH, have maintained viable identities in the PRT mode for their users. As stated above, PRTs funded by and representing national scientific funding agencies (e.g., the NSF or NIH in the United States, the JAEA or KEK in Japan, or the various national scientific agencies in the case of the European CRGs at the ESRF) which are open to the communities served by those agencies, also continue to be viable.

At ESRF, the advantages of CRGs are seen as (1) providing regular, flexible, and immediate access outside the proposal system for CRG members, who are often the most frequent users of the facility and (2) expanding the number of beamlines beyond the number that can be supported by the facility (because the CRG beamlines are funded by the operating group) and (3) one-third of the time on CRG beamlines is available to all users via the general proposal program. Twenty percent of beamlines at ESRF are managed by CRGs.

To address the difficulties noted above, ESRF requires:

1. At the outset, the CRG group must present a full proposal to ESRF. In the proposal, the group must show that the beamline adds something unique to the facility, that it is not a repeat of an existing beamline, and that its operation will be adequately supported financially. They must also show that the beamline will be constructed so that it can be operated by the general user in the proposal progam.
2. The CRG beamlines are reviewed periodically by independent review, as are all beamlines. If the financial support is deemed inadequate, the CRG arrangement can be terminated.

These conditions meet most of the problems encountered with PRTs in the United States.

In summary, the PRTs represent another mechanism for a scientist to obtain access to facilities. The advantages of PRTs are that they provide members with greater access to a facility than they could expect via the general proposal system. Thus, they provide members the opportunity to try experiments for which they would not normally be awarded the beamtime, enabling them to be more creative and innovative. In some cases, this allows for more flexibility both in access and in conducting experiments that require unique instrumental configurations. PRTs also provide a channel for producing experienced users who can make fewer demands on facility staff. The facility supplies the photons or neutrons free, but it benefits from the fraction of beamtime on these instruments that are required to be under the control of the facility.

In some cases, several of the above flexibilities may be available through the general proposal system or by being participants in a “Partner User Program” (APS) or having “programmatic” proposals accepted. In the case of “programmatic” proposals,a user is granted a long period of repeated access to a facility for a series of experiments on a particular problem. The disadvantage of PRTs is most visible when they are poorly funded or badly managed by the team running the PRT.

6.3.3 Access via cooperative agreements and by building instruments

(a) Binational agreements

One method of access to international synchrotron X-ray and neutron scattering facilities is via bilateral agreements between scientific agencies in different countries. An example is the US-Japan cooperative agreement in neutron scattering that involved the US Department of Energy (DOE) and the Japanese Scientific Funding Agency (known as Mombusho at the time); it was instituted in 1981 and is still current today. While this agreement was rather limited in scope, and based primarily on the high flux reactors at Brookhaven (shut down in 1986) and Oak Ridge National Laboratories, it enabled Japanese scientists to come for periods of a year or more to these US facilities, provided some specialized instrumentation which the Japanese installed at the US facilities, and provided some funding for US scientists to visit Japanese neutron scattering centers.

There seems to be continuing enthusiasm for extending such agreements at the agency level from the Japanese side. The Japanese equivalent of the National Science Foundation has formally expressed its enthusiasm for a similar agreement in the area of synchrotron X-ray radiation research. The DOE Office of Science view at present, however, is that such agreements should take place between institutions or at the facility level, not at the agency level.

In another example, the Advanced Photon Source has an agreement with the Australian Nuclear Science and Technology Organization (ANSTO) for some fraction of beamtime on selected beamlines for ANSTO scientists in exchange for contributions to the operating expenses for those beamlines.

(b) Access by building instruments

Access to a foreign facility can be obtained by building an instrument at that facility.
The Spallation Neutron Source (SNS) currently has in place two agreements with foreign agencies or institutions to construct and operate instruments at the SNS. These foreign institutions have the status of an Instrument Development Team (IDT), which has a role similar to that of Participating Research Teams (PRTs—see previous section). For reasons of standardization, efficiency, and uniformity of operation, the SNS prefers to operate the instruments. The two instruments are respectively: (1) an engineering neutron diffractometer (VULCAN) constructed with Canadian funds and administered by McMaster University and (2) a Neutron Spin Echo spectrometer to be constructed with funds from the German Helmholtz society and administered by the Jülich National Laboratory in Germany. In the latter case, German scientists will be placed at SNS with funds from Jülich as their part of the operating costs of the instrument.

The VULCAN instrument at the SNS is an excellent illustrative example of infrastructure built at a US major facility by scientists from outside the United States. The Canadian Foundation for Innovation (CFI) held a one-time $ 200 M call for proposals to support international facilities. In the call, $ 100 M was earmarked to fund items at international facilities within Canada and $ 100 M to fund infrastructure at international facilities outside Canada. The CFI funded a $ 15 M proposal from McMaster University to build the VULCAN instrument at SNS under the second category. CFI funds went to McMaster University, and McMaster dispersed funds to Oak Ridge National Laboratory, as necessary, to construct VULCAN. In return, McMaster secured access for participating Canadian scientists (1) 50 % of time on VULCAN; (2) 50 % of time on a second instrument, SEQUOIA; and (3) 50 % of a single instrument time spread over the remaining instruments at SNS, all for a period of 10 years. The 10-year period starts when the beam intensity at SNS exceeds that at ISIS.

Apart from the examples mentioned above for the United States, several other examples may be cited around the world:

- The Japanese built an inelastic neutron spectrometer (MARI) at the ISIS neutron facility in the United Kingdom
- India contributed to an inelastic neutron spectrometer at ISIS
- Australia has built and operates a hard X-ray beamline at the Photon Factory Synchrotron Facility in Tsukuba, Japan
- The ILL and the French CEA have teamed with the Japanese Atomic Energy Agency to construct a 3-dimensional neutron polarization analysis “cryopad” diffractometer at the JRR-3 reactor in Japan
- Scientists at the Synchrotron Radiation Research Center (SRRC) in Taiwan have teamed with their Japanese counterparts to construct and operate an inelastic X-ray scattering beamline at the Spring-8 Synchrotron Facility in Harima, Japan.

Beamline scientists associated with an instrument that their country operates in a facility in another country become “embedded” in the scientific community of that country, increasing international scientific collaborations.

However, it is to be noted that there is no reciprocal funding by any US agency for building or operating an instrument at a synchrotron X-ray or neutron facility in another country. This is apparently because no mandate exists for agencies such as the DOE or the NSF to fund instrumentation in other countries. NSF bilateral programs for scientific cooperation between the United States and other countries are generally used to fund scientific exchanges, visits, conferences, and workshops.

It is this panel’s view that international collaborations centered on instruments or equipment provided by one country and based at a synchrotron X-ray or neutron facility in another country is an important and useful way of providing scientific access to that facility, for providing resources and expertise that the host country then does not have to provide, and for fostering international scientific collaboration.

6.4 Barriers to Access and Factors Limiting Access

This section identifies some barriers to access, based on data and comments emerging from the questionnaires.

6.4.1 Knowledge of facilities and getting started

Acquiring sufficient knowledge of the facility to write a competitive proposal and to set up a successful experiment represents a barrier for new users. The summer schools held by the facilities, as well as the scientific meetings and workshops held by societies, are very useful. There is also a great deal of technical information on instruments on facility websites. However, gaining sufficient knowledge to set up and construct the first experiment, collect reliable data, and analyze it with confidence is difficult. Collaborating with an experienced user can be most helpful in getting started. Also, the instrument scientist can play a decisive role at both a scientific and technical level in creating successful access for first-time and inexperienced users, as discussed below.

Particularly, there is a significant barrier and overhead for infrequent users to initiate experiments at facilities abroad. It is interesting, for example, that the use of ILL by US scientists has decreased in the past 15 years, from 11% to the current 5 %. This may be partly because many “professional” neutron users who were accustomed to travel and use facilities abroad have retired. In this regard, programs such as the NSF Materials World Network and other programs that support an international research experience for young scientists are most important.

6.4.2 Visa restrictions and security clearances

Denial of access for security reasons at US national facilities remains a barrier to access. Most facilities in the world report that there were visa or laboratory security requirements that foreign nationals must meet before access is permitted (see Question 17 to facilities, Appendix 4). While this is expected, five US major facilities reported a significant number of denials based on security (see Question 18 to facilities, Appendix 4).

Informal interviews indicate that many of these denials are visa PhD graduate students, resident in the United States and working in US university research groups, who cannot get access. These students essentially have to pursue a different PhD research topic, which is unfortunate at a time when a goal is to expand the scientific community using synchrotron X-ray and neutron facilities. This is not a small problem, because at least 50 % of graduate students today are foreign nationals.

Also, since the early 2000s, foreign scientists are less inclined to pursue research at US facilities because of visa requirements and the uncertainty of access entering the United States. Thus, while security is important, it remains a barrier to access, particularly because of the uncertainty in how it is applied.

6.4.3 Building instruments at facilities abroad

In Section 4 above, it was noted that building instruments at foreign facilities enables access to that facility. It was noted that this takes place between Japan and Europe, as well as extensively within Europe. Also, many nations have built and are building instruments at US facilities. However, there are few if any examples of US groups or institutions building instruments at foreign facilities. Indeed, there is no apparent path for US scientists to secure the funds to build an instrument at a facility abroad. In this panel’s discussions with NSF, it was learned that while scientific collaborations with scientists abroad often drawing on foreign facilities are encouraged and supported, funding to build instruments or sample environment equipment at foreign facilities is specifically excluded. This important mode of access used by foreign nationals to get access, and often very independent access, at US facilities is not open to US scientists.

6.4.4 Mismatch between nation-to-nation and multinational facilities' access policies.

The difference between the access policies of national and multinational facilities (MNFs) can be a barrier to access and a source of misunderstanding. The distinction between the two policies is set out in Section 6.1 and discussed in Section 4. Essentially, national facilities can readily enter into and be part of nation-to-nation understandings on reciprocal use of major facilities between nations. That is, two nations can agree that their facilities are mutually open for use by scientists from the other nation. This operates well, for example, between France (e.g. LLB), Germany (e.g. HMI, Munich), and the United States (whose facilities are all national). However, it does not operate well between the United States and MNFs such as ILL and ESRF, which have different access policies (see Section 6.1.2) and are responsible to many member nations.

The access to a MNF is open chiefly to scientists from the member nations and associates that contribute directly to the annual budget. The percentage of the operating budget of ILL and ESRF that each member contributes is public information (see websites). Similarly, the percentage of beamtime awarded to scientists from each member nation is monitored and adjusted so that it is in line approximately with the percentage of budget provided. In this context, it is difficult to award a significant amount of time to scientists from non-member nations. This leads to friction, with some scientists in the United States implicitly expecting to have access to ILL and ESRF because US facilities are open to European scientists. Equally, some contributing members of the MNFs find it unreasonable that the United States, or any other nation, anticipates unrestricted access when the member nations have to contribute to the annual budget for access.

This policy mismatch needs to be recognized and appreciated simply as a mismatch. Each policy has its validity, and they do not join smoothly. The important role of MNFs in Europe, and their implications for US-European cooperation, was noted in a 1992 report of the National Science Board (NSB-90-172). This report noted (p.15) particularly that US government agencies have focused their efforts heretofore on bilateral cooperation with individual countries. Essentially, many nations have come together to build and provide the annual operating budget of a multinational major facility, a facility that would be difficult for any one nation to create individually. That the annual budget of a multinational facility is provided by several nations does not constitute “user fees.” The MNF facility directors report to these member nations and associates. A bilateral agreement cannot be simply struck by the directors of the MNF without clear agreement of all member nations. Any negotiated agreement must recognize the different structure of MNFs. Again, this mismatch of nation-to-nation and multinational facility access policies needs to be recognized and seen as a challenge to be negotiated.

ESRF and ILL are important because they are so large and play such a dominant role scientifically and internationally. Access to both ILL and ESRF is immediately possible by collaborating with a scientist from a member or associate nation. US use of ILL is running at 5-6 % (down from 10-11 % 10 years ago) and at 3 % at ESRF. With the “Millennium” instrument upgrade program in progress at ILL (since 2001) and the renewal planned at ESRF, ILL and ESRF will remain leaders for at least 10 years. In approximately 18 months, the announcement of the ESS is expected. Thus, while most new facilities are national, multinational facilities will remain very important and a smooth policy for mutual access with US facilities would be a great mutual asset.

6.5 New Facilities and Evolution of the Scientific Community

6.5.1 New synchrotron X-ray facilities coming on line will expand availability

As can be seen from Appendix 2 and 3, there has been and will be a large number of new synchrotron X-ray facilities coming on line. These include storage ring sources with capabilities similar to existing “third generation” sources (but with optimized technology and instrumentation and improved capabilities); examples include DIAMOND in the United Kingdom, SOLEIL in France, PETRA III in Germany and NSLS-2 at BNL. Also coming on line will be storage ring sources that provide synchrotron X-ray radiation capabilities to nations which currently do not have them (e.g., in Melbourne, Australia; the CLS in Canada; ALBA in Spain; INDUS-2 in India; or SESAME in the Middle East.)

Taken together with existing sources, these will provide access to advanced synchrotron X-ray radiation sources for a large number of nations in North America, Europe, and Asia. In Europe, the trend appears to be for nations to build one advanced national source and *in addition* to be part of a multinational consortium to utilize European sources such as the ESRF. It is anticipated that the user community in all these nations will increase significantly in the coming decade.

In addition to these sources, there are so-called “fourth generation” sources being constructed or planned in the U.S., Europe, and Japan that will provide a huge quantum jump in brilliance and other properties. X-ray Free Electron Laser (XFEL) sources can provide completely coherent beams with a peak brilliance of many orders of magnitude greater than existing third generation sources and pulses of the order of ~100 fs (but with only a few beamlines and operating at fixed photon energies). Another type of fourth generation source, based on so-called Energy Recovery Linacs (ERLs), also provide completely coherent beams in ~fs pulses but with lower brilliance than XFELs; ERLs can provide, in principle, many simultaneous beamlines like current storage ring sources. An XFEL source, the LCLS or Linear Coherent Light Source, is currently being commissioned at the Stanford SLAC facility and in Hamburg, Germany, and one is planned for Japan. The ERL sources have yet to be officially approved for construction.

The ERL sources will attract current synchrotron X-ray facility users who have reached the limits of what they can do at current third generation facilities, as well as pull in new users from the current scientific areas. The XFEL sources will be able to service a smaller number of users, but, in addition to the current user community, they may attract a completely new set of users. This new set of users would include those currently engaged in research with high-powered femtosecond lasers or those whose interests lie primarily in atomic or molecular physics or the physics of dense plasmas. While initially these sources will probably be used by PRT-type groups of scientists, because new technological frontiers will have to be crossed, they will inevitably evolve to being full user facilities. They will undoubtedly further rapidly change the nature of the user community.

6.5.2. New neutron scattering facilities coming on line will expand availability

New neutron scattering facilities coming on line will improve availability and modify the international balance. A list of new facilities coming on line and anticipated in the near future appears in Appendix 3.This list includes major upgrades as well as new facilities.

From a user perspective, the availability and access to neutron scattering facilities are determined largely by the number and quality of the neutron scattering instruments. For example, in the United States, the NCNR at NIST currently has the largest user program (i.e., the largest number of users per year) and highest productivity (i.e., most scientific papers published per year) in the United States. Yet the NCNR reactor (20 MW power) produces a modest neutron beam flux (4 x 10^14 neutrons/cm^2.sec), approximately one-third the flux of HFIR and ILL. The productivity of NCNR as a user facility dramatically increased with the installation of the new neutron guide hall and a spectrum of new instruments. The IPNS, with its quite modest flux (approximately 10 % that of ISIS,) has remained a productive facility because of its array of fine instruments. A comparison of the neutron flux at major international neutron facilities appears in Table 3, OSTP Report Gallagher 2002[1]. A detailed description of US facilities including instruments also appears there. The number of instruments at major international facilities in 2007 appears in this report in Figure 4.1.

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[1] Office of Science and Technology Policy (OSTP). 2002. Report of the Interagency Working Group on Neutron Science. *Report on the Status and Needs of Major Neutron Scattering Facilities and Instruments in the United States.*

ILL, now a 40-year-old facility, remains the world's leading neutron scattering facility. This is not because of the reactor neutron source but rather because of the large number (50) and wide variety of instruments and of cold (hot) source options. Particularly, over its 40 years life, ILL has had several major instrument development, rebuilding, improvement, and new instrument building programs. Since 2001, within the "Millennium" program, new neutron guides, new instruments, and much-improved instruments are being installed. With these upgrades, ILL hopes to maintain its leading position for the next 10-15 years.

While the importance of instruments is well known and runs through the OSTP Report of 2002, their degree of importance cannot be overemphasized. The United States has been through and is still in a low point in the availability of neutron facilities and instruments. As noted in the OSTP report and seen in Figure 4.1, even with the anticipated full complement of 24 instruments on the first target station at the SNS, the number of instruments in the United States will be 40 % of the number in Europe. In this context, instrument building should remain a priority in the United States. The guide hall and new instruments currently being completed at HFIR are a wise investment. Similarly, a second target station at SNS (before increasing the beam intensity) and a second guide hall at NCNR will greatly leverage investments already made at these facilities. In Europe, the instrument number is continually being increased and instruments upgraded (e.g., at ISIS).

China and Japan are emerging with major new neutron facilities (see Appendix 2 and Appendix 3). JPARC in Japan will be a world-class spallation neutron source. China is building both world-class reactor-based (CARR) and spallation-based (CSNS) neutron sources. With a complement of instruments, these new facilities in China and Japan will change the world balance of availability of neutron facilities between the East and the West. Access to these European and Asian facilities, particularly to the unique instruments in them, will be important to US scientists. The opportunity to participate in building specialty instruments at these facilities should also be an open option for US scientists in the same way that foreign scientists build instruments at US facilities.

The recommendation to invest in instruments at existing neutron facilities is consistent with the recommendation to invest in existing synchrotron X-ray facilities made in the NRC Report "Condensed-Matter and Materials Physics: The Science of the World Around Us" (also known as "CMMP 2010").

6.5.3 Changing nature of the user community

Over the past 25 years, there has been a significant change in the nature of the synchrotron X-ray and neutron scattering user community. Initially, the users of major facilities (particularly of neutron facilities) were chiefly physicists in the government labs (particular DOE labs) where the facilities were housed. As the facilities grew in capacity and capability, became centrally funded, and implemented user programs, they attracted a broad range of scientists and engineers from government, academe, and industry. The users now come from many fields of science, including chemistry, biology, geology, engineering, and medicine.

With this growth in the user community, there has been a change in the type of user. Many users now see synchrotron X-ray and neutron scattering as a routine tool in their suite of characterization techniques, and these users, although they appreciate the technique, have no interest in becoming an expert or building a career around the field. These users often have less sophistication with respect to the technique and bring a focus on attaining results. As such, their needs are centered on getting high-quality data and analysis with the minimum of difficulty. This shift in the user base has put strains on the instrument scientists and beamline operation because it places a strong emphasis on user-friendly instruments; 24-hour availability of instrument scientists; and online tools for experiment design, data reduction, and analysis. These trends are only going to continue with the newer, brighter sources coming online that are being planned and built throughout the world. With the resultant increases in data rates and experimental throughput, the shift of the user community away from “career users” towards less-sophisticated users will put new demands on instrument design, support staff, software, and all facets of user facility operation.

Over the past 25 years, there has also been a significant shift in the management of US synchrotron X-ray and neutron scattering facilities to expand the role of the facilities beyond supporting the mission of the local national laboratory and to include user programs as a core mission. This has lead to a steady growth in the user community, where now many of the scientists visiting synchrotron X-ray and neutron facilities are relatively inexperienced in the technique(s) and are using it to support their research program, which may have the main emphasis elsewhere. With the ongoing reorganization of the DOE-supported beamlines at Advanced Photon Source, the construction of the Spallation Neutron Source, and the expansion of the NIST Center for Neutron Research, the growth in both the synchrotron X-ray and neutron scattering user communities in the United States is expected to continue. With this growth of user programs, there will be a need for a more outwardly focused view in managing such experimental facilities. This would include: a large well-run proposal and beamtime allocation system; significant manpower allocations to high-throughput instruments; remote collaboration facilities for off-site users; central sample preparation laboratories and equipment; and a diverse and evolving sample environment suite.

Another issue that arises with the increased use of major scattering facilities by relatively inexperienced users is the possibility of users sending samples to the facility for an experiment without the user being present. This trend has already started in the areas of protein and powder diffraction. This is feasible for experiments requiring relatively simple and straightforward experimental conditions, but it becomes difficult when the experiment setup and conditions are complex.

6.5.4 Demands of Higher Experimental Throughput

With the increasing brightness of the major synchrotron X-ray and neutron sources, there has been an evolution in both the time it takes to run conventional experiments and a push towards new and more difficult experiments. For example, a temperature-dependent small-angle neutron scattering experiment, which 10 years ago took over one hour per temperature, can now be done in 5-10 minutes. This has allowed much finer temperature scans when searching for phase transitions (and the like) but has concomitantly required a much tighter integration between the instrument software and the sample environment control. No user wants to have to manually interact with an instrument every few minutes to change conditions. This is particularly true at synchrotrons, where sample data-collection times can often be measured in seconds. Measurement of the radius of gyration of a protein or protein assembly in dilute solution by small-angle X-ray scattering used to be a slow and laborious process requiring many hours of counting on both the sample and the background. At third-generation synchrotrons, data sets for complex biomolecules can now be routinely obtained from less than 100 μg of material, using capillary flow cells, in a matter of seconds. Microfluidic sample cells hold the promise of reducing sample quantities even further and allowing for routine *in-situ* measurements of folding kinetics and reactions. Opening the beamline hutch and changing samples or experimental conditions can take significantly longer than actually collecting the data.

The growing user community has also fueled a need for modern menu-driven interactive data acquisition and reduction software interfaces to instruments. The new neutron reflectometers being developed at the SNS will produce data at a rate that will easily outstrip the ability to analyze it. Users will want to arrive at the facility with their sample and leave with the fully-analyzed data set and the associated density profile (for reflectivity), crystal structure (for diffraction), or density of states (for inelastic scattering). The larger user community today naturally includes many less-experienced users, who seek “friendly” instrumentation and rely heavily on the instrument scientists.

6.5.5 The need for remote-collaboration infrastructure at facilities

There is a need for an increased emphasis on remote-collaboration capabilities at synchrotron X-ray and neutron facilities. With the evolution to large multi-disciplinary research teams, many times only a subset of the scientists can be present on site during a typical scattering experiment. Remote-collaboration capabilities would allow off-site members of the experimental team to participate in planning and reviewing data in real time during the experiment. This requires web-based interfaces to the data and possible audio and video links to the beamline. There should be flexibility in such systems so the user can choose which data sets are tagged for outside access by remote members of the research team. These same tools could also be used as an outreach tool for secondary and undergraduate education, allowing the results from research to be brought into the classroom. This trend of remote data viewing and interaction is different from remote control of instrumentation, where users can fully (or partially) control the instrument from an outside location. The idea of remote instrument control has yet to attain much popularity because of the inherent complications with safety (both human and instrument) and the difficulty of having every instrument parameter under computer control. In all cases, it is the facilities that must take the lead in developing these capabilities in response to user demand.

In addition to the potential for remote collaboration mentioned above, there is also a trend toward what might be termed "mail-in science." In this mode, users send their samples to the facilities, and the measurements are conducted entirely by instrument scientists. Although not suitable for many types of experiments (particularly if they involve sensitive or difficult-to-prepare samples or very complex experimental conditions), it can be useful for more routine experiments including powder diffraction, single-crystal diffraction, and some types of small-angle scattering and neutron reflectivity experiments. In general, if the samples can be readily transported and are stable, and if the scattering experiment can be easily defined with a standard set of optics, wave-vector range, and experimental conditions, it may be possible for some users to have their data collected for them.

This mode of doing science represents a shift in the duties of the instrument scientist and could allow for more flexibility in scheduling runs, instrument development, and maintenance, etc. Issues that would naturally arise and must be addressed include co-authorship and prioritizing order of measurement of the samples. In some fields, notably protein crystallography at synchrotron X-ray sources, this type of experiment is currently operating quite successfully. When a user has a suitable crystal, it can be shipped to the source for a well-defined set of diffraction experiments, and the data are returned to the user. The detailed analysis and structure determination and refinement is left to the user. With increasing brightness of sources and automation of data collection, it is likely that more scattering techniques will adopt this mode of operation for at least part of the available instrument time.

6.6 Critical Role of Instrument Scientists

Synchrotron X-ray and neutron scattering facilities employ facility scientists or 'instrument scientists" (IS). The IS is assigned to a specific instrument at the facility and is responsible for the operation and management of the instrument. The IS is very directly involved in the scheduling and scientific use of the instrument. The IS assists the users to plan experiments and prepare proposals.

In addition, the IS assists the users in carrying out the experiments on the instrument. During the experiment, the IS role is critical in advising the user whether the results obtained are genuine scientific results or rather some experimental artifact. He or she may also advise on the subsequent analysis of the data. The IS is a key element in making the facility “accessible” and making the science possible for the user.

ISs who understand the scientific goals and needs of the users, have an interest in the science being done on the instrument, and are motivated to extract the best possible science and data from the instruments make an enormous difference to the level of success of experiments. This is increasingly true as many experiments become more sophisticated and the user base expands to include scientists who are experts in their own fields but less familiar with synchrotron X-ray and neutron scattering facilities and instrumentation. It is also increasingly true as experimental time becomes shorter and data are collected more quickly.

It is generally agreed that instrument scientists need time and access to facility instruments to pursue their own scientific programs. It is important that they be scientists with identifiable scientific careers and that they have attractive career paths with clear promotion possibilities while remaining ISs. The ISs generally have continuing appointments at the facilities, although in some cases, such as at the Institut Laue Langevin, there are 5-year positions. It is important that these appointments have science as part of their “job description.”

Equally, ISs need incentive to conduct their own science or engineering. This is important firstly to attract excellent people as ISs. It is important so that the facility is a center of science as well as a user facility. It is important so that the ISs can continue to develop and grow scientifically and go on to a career in science elsewhere if they so choose. From the users’ perspective, it is important so that the IS can assist and collaborate with users on a scientific (e.g., experiment planning) level as well as a simply functional instrumental basis. This scientific collaboration is often a key to success for the less-experienced user.

An attractive scientific career for ISs is especially important for a new facility. This was stressed at the First US-China Workshop on Neutron Scattering held in November 2006. As the construction phase of a new facility draws to a close, the facility must move from a construction and instrument-building site to a scientific center. This means attracting individuals who have clear scientific interests and have a research program to bring to the facility. It is equally important for a mature facility to maintain scientific programs within the facility to avoid becoming a stale and unimaginative user facility. The ideal IS-user relationship is one in which the two are collaborators in a joint research project, each bringing unique expertise to the collaboration.

In responses to the questionnaire to facilities (see Section 4), it was learned that typically 15-20 % of beamtime was allocated to experiments by facility scientists and that this had not changed significantly in the past five years. Some facilities (e.g., NCNR and ISIS) require that instrument scientists write proposals themselves and compete directly as do users, so there is no or little allocation directly to ISs. It is difficult to judge whether 15-20 % is a sufficient allocation of beamtime. However, in the verbal responses, some ISs and many users expressed the view that facility scientists should have sufficient flexibility and time to pursue their own research and participate in genuine scientific collaborations with users.

At the same time, many interviewed expressed concern that ISs were under more and more pressure to assist users with less time for their own research programs. Essentially, the pace has increased. This concern seemed equally shared in newer as well as mature facilities. As facility flux increases, the pace will further increase. As the community grows, a larger fraction of the users will be less experienced with the use of in synchrotron X-rays and neutron scattering. They will be more dependent on gifted instrument scientists. Therefore, the role of the IS will be increasingly important in extracting the best science from facilities and ensuring scientifically rewarding access for users in the future.

Similarly, it will be important to support synchrotron X-ray and neutron scattering programs in universities that train graduate students with the skills to become instrument scientists. A stream of young scientists with the required competencies to become ISs who see an attractive career as an IS with good promotion possibilities is increasingly important for access as the pace of experiments accelerate and the user community expands.

SECTION 7: REPORT FINDINGS

In this section we summarize the findings of this report. We open with a summary of access policies. We go on to why scientists seek access to facilities abroad. We identify some specific means of obtaining access. We identify some factors that limit access. We conclude by discussing how the availability of facilities is evolving in the world, how the user community is evolving, how the nature of experiments at facilities is evolving and the perceived impact of these changes on access to major international facilities.

1. Basic Access Policies:

- None of the facilities responding to the questionnaire charge “user fees.” All major facilities have adopted the policy that government-funded laboratories provide the beam and instruments and users, who bring science and manpower, have access to these facilities without charge,. This is recognized worldwide as the most effective facility/user relationship.

- At all facilities responding, access is obtained by submitting a written proposal to the facility to conduct an experiment on a specific instrument or beamline. At all facilities, the proposals are reviewed by external reviewers or committees, and a recommendation for experimental time is made based on the scientific merit and feasibility of the proposal.

- Following the recommendation based on scientific merit, other factors may enter the decision to award time, such as national origin of user, balance of science proposed to the facility, previous record of achievement and other factors (see Section 4).

- In addition to the proposal program, time may be obtained by funding or being a member of a team that builds an instrument or beamline or other equipment (for example, a PRT or a CAT) at the facility (see below). Some other informal mechanisms, such as “Director’s time,” exist.

- At most European facilities, the travel and living expenses incurred by users in conducting an experiment at a facility are paid by the facility. At most US facilities, they are not.

- Major facilities may be classified as National (the operating budget is provided by a single nation) or as Multinational (operating budget provided by a consortium of nations and associates).

2. Bilateral access policy and multinational facilities

- The US policy for access to foreign facilities is effectively a bilateral, nation-to-nation understanding for reciprocal use of national facilities. It is an informal understanding that US scientists use foreign facilities and foreign scientists use US facilities as if there were no national barriers. This admirable and open-access policy operates well between individual nations having comparable availability of national facilities. However, it does not adapt well or join on well to multinational facilities such as ESRF and ILL that are supported by several member nations. The multinational facilities report to and rely upon support from many members and associates. They have to allocate use of the facility to scientists from member countries in approximate proportion to the member's support of the facility. The mismatch of the US nation-to-nation policy with access policies of multinational facilities needs to be recognized in the US simply as a mismatch to be addressed and transcended. It is a barrier to access. The mismatch of a bilateral policy and multinational facilities is not unique to neutrons and X-rays but has been cited as a barrier to collaboration in other fields (cf OECD Reports 1998, NSB Report 1990, Appendix 8).

- The chief multinational facilities are the ESRF and ILL, which are among the largest (in number of users and instruments) and most productive (scientific publications) facilities in the world. Current US use of ESRF is 3 % and ILL 5 %, down from 11 % 15 years ago. Negotiations between DOE (or NSF) and ESRF and ILL to establish collaboration agreements and to facilitate access to these multinational facilities is highly recommended.

- Most new synchrotron and neutron scattering facilities coming on line, under construction or planned will be national facilities (see Appendix 3). This is contrary to the finding of the OECD Megascience Forum Study of 1998, which projected a further concentration toward large regional and multinational facilities, probably in other fields. However, there are important exceptions, and access to multinational facilities will remain important. For example, the major upgrade in progress at ILL (2001-2008) and the major upgrade planned at ESRF means that these multinational facilities will remain world leaders in the coming 10 years. There is the major European X-ray Free Electron Facility coming on line in Hamburg. An announcement of the European Spallation Source (ESS) is anticipated (18 months). As stated for British scientists in the CCLRC 2005 Report, US scientists will seek access to the best possible facilities in the world.

- A bilateral, reciprocal access policy also functions well only if there is an approximate balance in the availability of facilities in the two nations. If this availability gets too far out of balance for too long the policy comes under strain. There have been significantly fewer neutron instruments available in the US than in Europe for many years. Even with the full complement of instruments (24) at SNS, the number of instruments in the USA will still be less than one half that in Europe (see OSTP Report 2002 and our Figure

1). In contrast, the availability of synchrotron beam lines in the US has been comparable and is projected to remain comparable to that in Europe or Asia.

2. Why we want Access:

- Access to foreign facilities is sought because foreign facilities may have:
  1. Unique instruments or specialty instruments not available in the US or the competition for certain instruments in the US may be high.
  2. Unique or specialty sample environment facilities or sample handling capability not available in the US.
  3. Unique or specialty scientific programs not being pursued in the US.

Until relatively recently, there were, for example, no spin-echo or high-energy resolution quasielastic spectrometers in the US. At present, there are few Time of Flight (TOF) spectrometers for inelastic neutron scattering in the US, especially ones that combine high energy resolution and high beam intensity.

3. Means of Obtaining Access:

1. Scientific Collaborations

- Access to foreign facilities can always be obtained by collaborating with foreign scientists. For example, proposals to multinational facilities that include an investigator from a member country of the facility are immediately classified as a member-country proposal. At many European facilities, more than one half of the teams conducting experiments contain a foreign national. Collaborations involving US scientists need to be encouraged and supported financially.

2. Cooperative agreements

- Access can be obtained via nation-to-nation cooperative agreements such as the US-Japan cooperative agreement in neutron scattering.

3. Building Instruments or Sample Environment Facilities

- Access can be obtained by building an instrument at a foreign facility. For example, Canadian scientists are currently building the VULCAN instrument and German scientists the neutron spin echo (NSE) instrument at the SNS. Japan has been particularly successful in placing instruments and gaining access at facilities abroad. However, we found no examples of instruments built by US scientists at facilities abroad. Indeed, there is no mechanism for funding instrument or sample environment building by individual US scientists abroad. This is a major gap in routes to access for US scientists and engineers at foreign facilities.

- Access can be obtained by creating or participating in a Participating Research Team (PRT). PRTs are also denoted Collaborating Access Teams (CATs) and are called Collaborating Research Groups (CRGs) in Europe. This mechanism has been used extensively by US scientists at US synchrotron facilities but is now somewhat out of favor. The CRG in Europe is regarded as an important and successful means of flexible access. At ESRF, for example, the CRG must demonstrate that the CRG instrument is unique, that the instrument will be constructed following facility guidelines and the CRG is reviewed periodically to ensure that funding for operation remains adequate. Although it may need review in the USA, the PRT or CAT remains an important access mechanism.

4. Factors Affecting Access and Barriers to Access

- Knowledge of facilities remains a barrier to initiating experiments at foreign facilities. Getting started, usually within a collaboration, is also a barrier.

- Restrictions on visas for entry into the USA and the security reviews of non-US citizens at DOE facilities which may result in delay or limits on access remain a barrier to access. For example, 50-75 % of science and engineering graduate students in the USA are foreign nationals chiefly from Asia. The security review at DOE facilities and on occasions the lack of transparency of the process and delay of access for these students often means that these students elect to pursue other research.

5. Availability of Facilities and the Community is Evolving

- New facilities are coming on line that will improve access and modify international balance. The US has been through (and still is in) a low point in availability of neutron instruments. SNS will greatly improve the balance in number and sophistication of instruments between US and Europe, for example. However, the number of instruments in the US will remain significantly below that in Europe without a second target station at SNS plus a full complement of instruments, new guide halls at HFIR and NCRC and significant expansion of the number of instruments at LANSCE. Availability of synchrotron X-ray facilities in the US has been much better. However, limited operating funds for X-ray facilities, which limits the length of time the facility can operate in a year and the number of instruments scientists it can support, appears to be a limiting factor for X-Ray facilities.

- The number of users and the number of accepted proposals on a facility or in a region of the world is highly correlated with the number of instruments at the facility or in the region (see section 4.5).

- Specifically, funds devoted to beamlines and instruments yield rich returns in terms of increased availability of X-rays and neutrons for users and the productivity of facilities in terms of scientific publications arising from experiments. This is particularly true for funds devoted to the continuing upgrade of guide halls, beamlines and instruments at existing and newly completed facilities. This is the basis of the recommendation in the NRC report, CMMP 2010, that the priority for funds at X-Ray facilities should be on beamline upgrades and sample environment facilities. NIST and ILL are important examples where continuing expenditure on instruments has created an outstanding neutron scattering facility.

- Japan and China are building major new facilities that will change the balance of availability of major facilities between the East and the West. JPARK will be a sophisticated major facility sought by scientists in the West. China is building both world-class reactor (CARR) and spallation (CSNS) neutron sources. This is a significant change and it is likely that US scientists will seek access to these facilities.

- ILL and ESRF with their upgrades are predicted to remain world leading facilities for the next 10 years in size, in spectrum of instruments, in sample environment facilities and in scientific productivity. With the upgrades to US synchrotron X-Ray that are currently being planned, we expect the United States will have facilities comparable to the best in the world in the X-Ray field when these plans are implemented.

6. Critical role of Instrument Scientists

- The nature of the user community is evolving. While in the early days many users were experts in the use of neutrons and X-rays, today most users are experts in their own fields but largely unfamiliar with neutron and X-ray scattering. As the user community in the US grows, this trend will continue. This evolution will place increasing reliance and demand on facility instrument scientists to guide users to the best use of facilities. Scientifically productive access for most users will require increasing intervention and assistance from instrument scientists with planning experiments, with “hands-on” assistance during the experiment and with assistance in interpreting and analyzing the data.

- With increased beam intensity and spectrometer efficiencies, data will be collected more quickly and the length of time of experiments will be reduced. In many cases, this will also place increasing reliance on instrument scientists for assistance at a scientific level during the experiment to make the best use of the facility.

- Given the evolving nature of the user community and increased data collection rates, concern was expressed that instrument scientists are under increasing time pressure as they assist users. This has made the position as an instrument scientist less attractive and made it more difficult for instrument scientists to assist users at a scientific level. It also made it difficult for instrument scientists to maintain an independent research program at the facility. Ensuring that instrument scientists have sufficient time to pursue their own research interests and sufficient time to carry out their own experiments is essential in making the position of instrument scientist attractive.

- Specifically, users expressed the view that assistance at a science level was often critical for the success of their experiments. As the pace of experiments increases and as the user community expands to include less experienced users, instrument scientists will become increasingly important in securing scientific access for users. It is therefore critical that they have an attractive career path with clear promotion prospects and time to pursue their own science as well as to devote to user teams. Equally, it is important to support the educational research programs in universities that train new instrument scientists to ensure a continuing flow of bright young scientists into the X-ray and neutron scattering fields.

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Simon Billinge
Marty Blume
Colin Carlile
Sung-Min Choi
Steven Dierker
Patrick Gallagher
Bruce Gaulin
Peter Gehring
Joy Andrews Hayter
Steve Hulbert
Alan Hurd
Gene Ice
Chi-Chang Kao
Efim Kats
Tonya Kuhl
John Larese
Laurence Lurio
Dennis Mills
David Moncton
Daniel Neumann
Philippe Nozieres
Sungil Park
Roger Pynn
Moonhor Ree
John Root
John Rush
Reinhard Scherm
Helmut Schober
Gopal Shenoy
George Srajer
William Stirling
Gerlind Sulzenbacher
Andrew Taylor
Raymond Teller
Guebre Tessema
Christian Vettier
Susanne Weigert
Lane Wilson
Herman Winick

SECTION 8: APPENDICES

ACCESS TO MAJOR INTERNATIONAL X-RAY AND NEUTRON FACILITIES

APPENDICES:

1) **"Proposed Report" Statement from CISA to APS Board in November 2005** ("Goals & Scope" document)

2) **List of Current Major Synchrotron X-Ray & Neutron Facilities**

3) **List of Future Major Synchrotron X-Ray & Neutron Facilities**

4) **Questionnaire to Synchrotron X-Ray & Neutron Facilities**

5) **Questionnaire to Synchrotron X-Ray & Neutron User Groups & Societies**

6) **List of Facilities, User Groups and Societies that responded to questionnaires**

7) **Meetings Held**

8) **Previous Reports on Access**

9) **List of Acronyms**

Appendix 1

ACCESS TO MAJOR INTERNATIONAL FACILITIES

A PROPOSED REPORT BY THE
COMMITTEE ON INTERNATIONAL SCIENTIFIC AFFAIRS
AMERICAN PHYSICAL SOCIETY

PREAMBLE

In 2004, the Committee on International Scientific Affairs (CISA) of the APS decided to create subcommittees to investigate specific topics of an international nature that are projected to have a significant long-term impact on physics and related sciences. The ability to conduct world-class research depends increasingly on access to major scientific user facilities worldwide. CISA therefore decided to form a subcommittee to examine the evolving conditions for access to major international scientific user facilities and the projected international interdependence of major user facilities.

GOAL AND SCOPE OF THE STUDY

The central goal is to provide an assessment of the issues involved with access to major facilities for physics research. Terms of access to these facilities appear to be evolving. This evolution appears to be different in different fields of physics and in different regions of the world. The aim is to provide information on the conditions and requirements for getting experiments approved in different fields and in different regions of the world and to assess its impact on access for US physicists.

Specifically the study will examine the following questions related to access to major scientific facilities:

- What is the process and what are the conditions that must be met to get an experiment proposal approved? This includes the review process for proposals, possible requirements of collaboration with local scientists, acceptance of proposals from non-participating countries, success rates of proposals, etc.

- Are there issues with national security or visas for scientists trying to do experiments?

- Is use of the facility free of charge to the user for research that will be in the public domain?

- Have access issues for scientists doing experiments at the major scientific facilities changed significantly in the past 5-10 years and how are they expected to change in the next 5-10 years?

The study will survey current major scientific user facilities in the areas of nuclear and particle physics; and x-ray and neutron sources along with the associated user groups and societies to obtain information on the conditions for access as they impact the user. It will encompass major facilities throughout the world (not just the USA) and will present a users perspective. We chose not to include the facilities for inertially confined fusion and magnetically confined fusion at this time since they will be included in an ongoing review by the National Research Council as part of Plasma Physics 2010.

A report intended for the membership of the American Physical Society is envisaged. It will be, hopefully, of informational interest outside the APS.

Appendix 2

CURRENT MAJOR X-RAY AND NEUTRON FACILITIES

CURRENT MAJOR SYNCHROTRON FACILITIES

Asia/Pacific

Australian Synchrotron, Melbourne, Australia
Website:
http://www.synchrotron.vic.gov.au/content.asp?Document_ID=1
Address: Level 17, 80 Collins St
Melbourne 3000 VIC Australia
Email: **contact.us@synchrotron.vic.gov.au**
Director: Robert Lamb, info@synchrotron.org.au
Start Date: 2007

Beijing Synchrotron Radiation Facility (BSRF), Beijing, China
Website: **http://www.ihep.ac.cn/bsrf/english/main/main.htm**
Address: Beijing Synchrotron Radiation Laboratory
Institute of High Energy Physics
Beijing, 100039
P.R.China
Director: Hu Tiandou, **hutd@mail.ihep.ac.cn**

Raja Ramanna Center for Advanced Technology (INDUS-1 & INDUS-2), Indore, India
Website: **http://www.cat.ernet.in/index.html**
Address: Raja Ramanna Centre for Advanced Technology
Department of Atomic Energy
Indore, M.P – 452 013
India
Director: Dr. Vinod Chandra Sahni, **vcsahni@cat.ernet.in**
INDUS-2 Contact: Sh. S. Kotaiah, Project Manager, Indus-2
P.O.: CAT, Indore – 452 013
Fax: +91-731-2488852
Email: skt (at) cat.ernet.in

National Synchrotron Radiation Laboratory (NSRL), Hefei, China
Website: http://www.nsrl.ustc.edu.cn/en/
Address: NSRL
University of Science and Technology of China
Hefei, Anhui
P.R. China
Director: He Duohui

Email: Office: **gongxm88@ustc.edu.cn**, **nsrl@ustc.edu.cn**
For users: zdh@ustc.edu.cn

National Synchrotron Radiation Research Center (NSRRC), Hsinchu, Taiwan, R.O.C
Website: **http://www.nsrrc.org.tw/**
Address: 101 Hsin-Ann Road
Hsinchu Science Park
Hsinchu 30076
Taiwan, R.O.C
Director: Keng S. Liang, **ksliang@nsrrc.org.tw**
Email: info@nsrrc.org.tw

Photon Factory (PF) at KEK, Tsukuba, Japan
Website: **http://pfwww.kek.jp/**
Address: Oho 1-1,
Tsukuba, Ibaraki, 305-0801
Japan
Director: Matsushita, Tadashi, tadashi.matsushita@kek.jp
Email: users.office@post.kek.jp

Pohang Accelerator Laboratory, Pohang, Korea
Website: http://pal.postech.ac.kr/
Address: San-31
Hyoja-dong
Pohang, Kyungbuk, 790-784
Korea
Director: Moonhor Ree, ree@postech.edu
Email: kischool@postech.ac.kr, kny1052@postech.ac.kr

Shanghai Synchrotron Radiation Facility (SSRF), Shanghai, China (2009)
Website: http://www.sinap.ac.cn/english/index.html
Address: Shanghai Institute of Applied Physics
Chinese Academy of Sciences
Shanghai, P.R. China
Director: Hongjie Xu, **Xuhj@ssrc.ac.cn**

Singapore Synchrotron Light Source (SSLS), Singapore
Website: **http://ssls.nus.edu.sg/**
Address: Singapore Synchrotron Light Source
National University of Singapore
5 Research Link
Singapore 117603
Singapore
Director: Herbert O. Moser, moser@nus.edu.sg

Super Photon Ring – 8 GeV (Spring8), Hyogo, Japan
Website: http://www-xfel.spring8.or.jp/
Address: Super Photon Ring – 8 GeV (Spring8)
RIKEN
Harima Institute
Hyogo 679-5148, Japan
Director: Hideo Kitamura
E-mail: **sp8jasri@spring8.or.jp**
Start Date: 2006

Europe

ANKA Synchrotron Strahlungsquelle, Karlesruhe, Germany
Website: http://ankaweb.fzk.de/
Address: Forschungszentrum Karlsruhe
Hermann-von-Helmholtz-Platz 1
76344 Eggenstein-Leopoldshafen
Germany
Director: Dr. Tilo Baumbach
E-mail: info@fzk.de

Berliner Elektronenspeicherring-Gesellschaft für Synchrotronstrahlung (BESSY), Berlin, Germany
Website: http://www.bessy.de
Address: BESSY GmbH, Albert-Einstein-Str.15
12489 Berlin
Germany
Director: Prof. Dr. Wolfgang Eberhardt, eberhardt@bessy.de

Centre Laser Infrarouge d'Orsay (CLIO), Orsay, France
Website http://clio.lcp.u-psud.fr/
Address: CLIO/LCP
Bat. 201 - P2
Campus Universitaire
91405 ORSAY Cedex
France

DAFNE Light Laboratory, Rome, Italy OMIT not user facilty
Website: **http://www.lnf.infn.it/esperimenti/sr_dafne_light/**
Address: INFN-LNF, Via Enrico Fermi 40
00044, Frascati (RM)
Italia
Director: Antonio Grilli, Antonio.Grilli@lnf.infn.it

Diamond Light Source, United Kingdom

Website: http://www.diamond.ac.uk/default.htm
Address: Diamond House
Chilton
Didcot
Oxfordshire
OX11 0DE
Director: Professor Gerd Materlik
Email: dlsenquiries@diamond.ac.uk
Start Date: 2007

Dortmund Electron Test Accelerator (DELTA), Dortmund, Germany
Website: http://www.delta.uni-dortmund.de/index.php?id=2&L=1
Address: Institut für Beschleunigerphysik und Synchrotronstrahlung
Universität Dortmund
Maria-Goeppert-Mayer-Str. 2
44221 Dortmund
Germany
Director: Prof. Dr. Metin Tolan, tolan@physik.uni-dortmund.de

Elettra Synchrotron Light Source, Trieste, Italy
Website: http://www.elettra.trieste.it/index.php
Address: Incrotrone Trieste S.C.p.A. di interesse nazionale
Strada Statale 14 – km 163,5 in AREA Science Park
34012 Basovizza, Trieste
Italy
Director: Alfonso Franciosi
Email: info@elettra.trieste.it, useroffice@elettra.trieste.it

European Synchrotron Radiation Facility (ESRF), Grenoble, France
Website: http://www.esrf.fr/
Address: ESRF
6 Rue Jules Horowitz
BP 220
38043 Grenoble Cedex 9
France
Director: W.G. Stirling, stirling@esrf.fr

Hamburger Synchrotronstrahlungslabor (HASYLAB) at DESY,
Hamburg, Germany (site of DORIS III, FLASH, XFEL)
Website: http://www-hasylab.desy.de/
Address: DESY – HASYLAB
Notkestrasse 85
22607 Hamburg
Germany
Director: Prof. Dr. Edgar Weckert, edgar.weckert@desy.de

MAX-lab, Lund, Sweden
Website: **http://www.maxlab.lu.se/**
Address: MAX-lab
Box 118
22100 Lund
Sweden
Director : Nils Mårtensson, **nils.martensson@maxlab.lu.se**

Siberian Synchrotron Radiation Centre (SSRC) – VEPP 3/VEPP 4, Novosibirsk, Russia
Website: http://ssrc.inp.nsk.su/
Address: SSRC
Lavrentyev av. 11
Budker INP
Novosibirsk 630090
Russia
Director: Academician Gennady N. Kulipanov**,**
G.N.Kulipanov@inp.nsk.su

Source Optimisée de Lumière d'Energie Intermédiaire du LURE (**SOLEIL),** France
Website: **http://www.synchrotron-soleil.fr/anglais/**
Address: L'Orme des Merisiers
Saint-Aubin - BP 48
91192 Gif-sur-Yvette Cedex

Swiss light source (SLS) at the Paul Scherrer Institut
Website: **http://sls.web.psi.ch/**
Address: Paul Scherrer Institut
User Office
5232 Villigen-PSI
Switzerland
Director: Friso van der Veen, friso.vanderveen@psi.ch

Synchrotron Radiation Source (SRS), Daresbury, U.K.
Website: **http://www.srs.ac.uk/srs/**
Address: SRS
CCLRC Daresbury Laboratory
Warrington, Cheshire
U.K. WA4 4AD
Director: Dr. Tracy Turner, **t.s.turner@dl.ac.uk**

North America

Advanced Light Source (ALS), Berkeley, California, USA

Website: http://www-als.lbl.gov/
Address: ALS
Berkeley Lab
1 Cyclotron Rd
MS 80R0114 (For Kirz)
Berkeley, CA 94720
Director: Roger Falcone
Email: alsuser@lbl.gov

Advanced Photon Source (APS), Argonne, Illinois, USA
Website: http://www.aps.anl.gov/
Address: APS
Argonne National Laboratory
9700 S. Cass Avenue
Argonne, IL 60439
Director: J.M. Gibson, jmgibson@aps.anl.gov
Email: apsuser@aps.anl.gov

Canadian Light Source (CLS), Saskatoon, Canada
Website: http://www.lightsource.ca/
Address: Canadian Light Source Inc.
University of Saskatchewan
101 Perimeter Road
Saskatoon, SK.
Canada. S7N 0X4
Director: William Thomlinson, william.thomlinson@lightsource.ca
Email: cls@lightsource.ca
Start Date: 2004
Beamlines: 7, plus 7 more projected in the future

Cornell High Energy Synchrotron Source (CHESS), Ithaca, New York, USA
Website: http://www.chess.cornell.edu/
Address: Cornell High Energy Synchrotron Source
200L Wilson Lab
Rt. 366 & Pine Tree Road
Ithaca, NY 14853
Director: Sol Gruner, smg26@cornell.edu

National Synchrotron Light Source (NSLS), Brookhaven, New York, USA
Website: http://www.nsls.bnl.gov/
Address: NSLS Chairman’s Office
Brookhaven National Laboratory
P.O. Box 5000, Bldg. 725B
Upton, NY 11973-5000

Director: Steven Dierker, dierker@bnl.gov
Email: Chairman's Office: ljmiller@bnl.gov

Stanford Synchrotron Radiation Laboratory (SSRL), Menlo Park, California, USA
Website: **http://www-ssrl.slac.stanford.edu/**
Address: Stanford Linear Accelerator Center
2575 Sand Hill Road
Menlo Park, CA 94025
Director: Joachim Stöhr, Stohr@ssrl.slac.stanford.edu
Email: knotts@SLAC.Stanford.edu

Synchrotron Radiation Center (SRC), Madison, Wisconsin
Website: **http://www.src.wisc.edu/**
Address: Synchrotron Radiation Center
3731 Schneider Dr.
Stoughton, WI 53589-3097
Director: Joseph Bisognano, jbisognano@src.wisc.edu

South America

Laboratorio Nacional de Luz Síncrotron (LNLS) Sao Paolo, Brazil
Website: **http://www.lnls.br/**
Address: Caixa Postal 6192
CEP 13084-971
Campinas, SP
Brazil
Director: José Antônio Brum, **brum@lnls.br**
Email: secre@lnls.br

CURRENT MAJOR NEUTRON FACILITIES

Asia/Pacific

DHRUVA Research Reactor, Trombay, India
Website: **http://www.barc.ernet.in/**
Address: Bhabha Atomic Research Centre,
Trombay,
Mumbai - 400 085
India
Director: Mr. S.K. Sharma, **sksharma@apsara.barc.ernet.in**

High-flux Advanced Neutron Application Reactor (HANARO), Taejon, South Korea
Website: **http://hanaro.kaeri.re.kr/english/index.html**
Address: P.O. Box 105
Tokchin-dong, Yusong-ku
Taejon, 305-600
South Korea
Director: Young-Jin Kim, youkim@kaeri.re.kr

ISSP Neutron Science Laboratory, Kashiwa, Japan
Website: http://neutrons.issp.u-tokyo.ac.jp/?easiestml_lang=en
Institute associated with JRR-3 below
Address: Kashiwanoha 5-1-5
Kashiwa 277-8581
Japan
Director: Hideki Yoshizawa
Email: **wnabe@issp.u-tokyo.ac.jp**

Japan Research Reactor 3 (JRR-3), Japan
Website: http://www.issp.u-tokyo.ac.jp/labs/neutron/jrr3/
Address: Department of Research Reactor
Japan Atomic Energy Research Institute (JAERI)
Tokai Research Establishment
Tokai, Ibaraki-Ken, 319-1195
Japan
Email: issiki@jrr3fep2.tokai.jaeri.go.jp

Director: Takashi Kamiyama, takashi.kamiyama@kek.jp

Open Pool Australian Light-Water Reactor (OPAL), Lucas Heights, Australia
Website: http://www.ansto.gov.au/opal.html
Address: Australian Nuclear Science and Technology Organisation
Lucas Heights, New South Wales
Australia
Email: enquiries@ansto.gov.au
Start Date: 2007

Europe

Forschungsneutronenquelle Heinz Maier-Leibnitz (FRM-II), Munich, Germany
Website: http://www.frm2.tum.de/
Address: ZWE FRM-II
Lichtenbergstraße 1
85747 Garching
Director: Prof. Dr. Winfried Petry, winfried.petry@frm2.tum.de
Email: userinfo@frm2.tum.de

Frank Laboratory of Neutron Physics (FLNP), Dubna, Russia
Website: **http://nfdfn.jinr.ru/**
Address: Frank Laboratory of Neutron Physics
Joint Institute for Nuclear Research
141980 Dubna, Moscow Region
Russian Federation
Director: Belushkin Aleksandr Vladislavovich, belushk@nf.jinr.ru

GKSS Geesthacht, Geesthacht, Germany
Website: **http://www.gkss.de/index_e_js.html**
Address: Postfach 1160
21949 Geesthacht
Germany
Director: Prof. Dr. Wolfgang A. Kaysser, **wolfgang.kaysser@gkss.de**

Hahn-Meitner Institute, Berlin, Germany
Website: **http://www.hmi.de/index_en.html**
Address: HMI
Glienicker Str. 100
14109 Berlin
Director: Michael Steiner, **Steiner@hmi.de**
Email: robertson@hmi.de

Institut Laue-Langevin (ILL), Grenoble, France
Website: http://www.ill.eu/
Address: BP 156
6, rue Jules Horowitz
38042 Grenoble Cedex 9
France
Director: Richard Wagner, wagner@ill.eu
Email: welcome@ill.eu

Interfacultair Reactor Institute (IRI), Delft, The Netherlands
Website: http://wwwtest.iri.tudelft.nl/
Address: Reactor Institute Delft
Mekelweg 15, 2629 JB Delft
Netherlands
Director: Dr. T.H.J.J. van der Hagen
Email: secretary-rid@iri.tudelft.nl

ISIS - Rutherford Appleton Laboratory, United Kingdom
Website: http://www.isis.rl.ac.uk/
Address: ISIS Pulsed Neutron & Muon Source
Rutherford Appleton Laboratory
Chilton
Didcot OX11 0QX
United Kingdom
Director: Andrew Taylor, Andrew.Taylor@rl.ac.uk

KFKI, Budapest, Hungary
Website: http://www.kfki.hu/indexeng.html
Address: KFKI
Hungarian Academy of Sciences
H-1525 Budapest 114, P.O.B. 49

Leon Brillouin Laboratory, Gif-sur-Yvette, France
Website: http://www-llb.cea.fr/index_e.html
Address: CEA Saclay
Bâtiment 563
91191 Gif-sur-Yvette cedex
France
Director: Philippe Mangin, Mangin@lpm.u-nancy.fr

Swiss spallation neutron source (SINQ) at the Paul Scherrer Institut (PSI)
Website: http://sinq.web.psi.ch/
Address: Paul Scherrer Institut
User Office
5232 Villigen-PSI

Switzerland
Director: Kurt N. Clausen, kurt.clausen@psi.ch

Petersburg Nuclear Physics Institute, Gatchina, Russia
Website: **http://www.pnpi.spb.ru/**
Address: PNPI RAS Gatchina
Leningrad District 188300
Russia
Acting Director: Vladimir M. Samsonov

North America

The Canadian Neutron Beam Centre (CNBC), Ontario, Canada
Website: http://neutron.nrc-cnrc.gc.ca
Address: National Research Council Canada
Building 459, Station 18
Chalk River Laboratories
Chalk River, Ontario
Canada K0J 1J0
Director: John Root, John.Root@nrc.gc.ca

High Flux Isotope Reactor (HFIR), Oak Ridge, Tennessee
Website: http://neutrons.ornl.gov/
Address: HFIR Center for Neutron Scattering
Oak Ridge National Laboratory
P.O. Box 2008
Oak Ridge, TN 37831
Executive Director: Kelly Beierschmitt

Intense Pulsed Neutron Source (IPNS), Argonne National Laboratory, Illinois
Website: **http://www.pns.anl.gov/**
Address: IPNS
Argonne National Laboratory
9700 S. Cass Ave
Argonne, IL, 60439-4814
Director: Raymond Teller, **rgteller@anl.gov**
Close Date: December 2007

Manuel Lujan Jr. Neutron Scattering Center at LANSCE, Los Alamos Natl. Laboratory
Website: **http://lansce.lanl.gov/lujan/index.html**
Address: Manuel Lujan Jr. Neutron Scattering Center at LANSCE
Los Alamos National Laboratory

P.O. Box 1663
Los Alamos, NM 87545
Director: Alan J. Hurd, ajhurd@lanl.gov

National Institute of Standards and Technology Reactor (NIST),
Gaithersburg, Maryland
Website: **http://www.ncnr.nist.gov/**

Address: NIST Center for Neutron Research
Materials Science and Engineering Laboratory
National Institute of Standards and Technology
100 Bureau Drive, MS 8562
Gaithersburg, MD 20899-8562
Director: Patrick Gallagher, **patrick.gallagher@nist.gov**

Spallation Neutron Source (SNS)
Website: **http://www.sns.gov**
Address: SNS
P.O. Box 2008 MS6477
Oak Ridge, TN 37831-6477
Director: Ian S. Anderson, andersonian@ornl.gov

Appendix 3

FUTURE MAJOR SYNCHROTRON X-RAY AND NEUTRON FACILITIES

FUTURE MAJOR SYNCHROTRON X-RAY FACILITIES

Asia/Pacific

Spring-8 Compact SASE Source (SCSS)
Website: http://www-xfel.spring8.or.jp/
Address: Super Photon Ring – 8 GeV (Spring8)
RIKEN
Harima Institute
Hyogo 679-5148, Japan
E-mail: **sp8jasri@spring8.or.jp**

Europe

ALBA Synchrotron Light Facility, Cerdanyola del Vallès, Spain
Website: **http://www.cells.es/**
Address: Consorcio para la Construcción, Equipamiento y Explotación del Laboratorio de Luz de Sincrotrón
Apartado De Correos 68
08193 Bellaterra
Spain
Start Date: 2008
Beamlines: 7 (Projected Number)

Petra III, Hamburg, Germany
Website: **http://petra3.desy.de/**
Address: Deutsches Elektronen-Synchrotron DESY
Notkestraße 85
22607 Hamburg
Germany
Email: **petra3@desy.de**
Start Date: 2009
Beamlines: 14 (Projected Number)

FLASH, Hamburg, Germany
Website: http://hasylab.desy.de/facilities/flash/
Address: Deutsches Elektronen-Synchrotron DESY
Notkestraße 85

22607 Hamburg
Germany
Email: hasylab@desy.de
Start Date: October 2008
Beamlines: 4 (Current)

Paul Scherrer Institut X-ray Free Electron Laser Project (PSI X-FEL), Switzerland
Website: http://fel.web.psi.ch/
Address: Paul Scherrer Institut
User Office
5232 Villigen-PSI
Switzerland
Start Date: Design Studies, Full proposal submission: 2011

The European X-ray Laser Project X-ray Free-Electron Laser (**XFEL**), Hamburg, Germany
Website: **http://www.xfel.net/en/**
Address: Deutsches Elektronen-Synchrotron DESY
Notkestraße 85
D-22607 Hamburg
Germany
Start Date: Construction to begin in 2007; commissioning of the facility could start in 2013.

Middle East

Synchrotron-light for Experimental Science and Applications in the Middle East (SESAME), Jordan
Website: **http://www.sesame.org.jo/Contact/mail.aspx**
Address: **Al-Balqa Applied University**
Salt - 19117
Jordan
Director: Herwig Schopper, herwig.schopper@cern.ch
Start Date: 2007
Beamlines: 6 (Projected Number), Plus 6 more in the future

North America

CHESS-ERL Source
(Has not been approved for funding yet)
Website: **http://erl.chess.cornell.edu/**
Address: Energy Recovery Linac (ERL)
Cornell High Energy Synchrotron Source
200L Wilson Lab
Rte 366 & Pine Tree Road

Ithaca, NY 14853
Director: Principal Investigator: Sol Gruner, smg26@cornell.edu

Coherent Infrared Center Advanced Light Source (CIRCE), Berkeley, California
(Has not been approved for funding yet)
Website: http://circe.lbl.gov/
Address: Advanced Light Source
Berkeley Lab
Berkeley, CA 94720

Jefferson Lab (JLab) FEL, Virginia
(not been approved for funding yet. Web site indicates FEL closed in May 2007 for upgrades and will reopen in March 2008.
Website: http://www.jlab.org/FEL
Address: 12000 Jefferson Avenue
Newport News, Virginia 23606

Linac Coherent Light Source (LCLS), Stanford, California, USA
Website: http://www-ssrl.slac.stanford.edu/lcls/
Address: Stanford Linear Accelerator Center (SLAC)
2575 Sand Hill Road MS 18
Menlo Park, CA 94025
Director: John Galayda, galayda@slac.stanford.edu
Email: lcls@slac.stanford.edu
Start Date: 2009

NSLS-II (National Synchrotron Light Source II), Upton, New York
Website: http://www.nsls2.bnl.gov/
Address: NSLS-II Project Office
Brookhaven National Laboratory
Building 817
P.O. Box 5000
Upton, NY 11973-5000
Director: Steven Dierker, dierker@bnl.gov
Start Date: 2012

SYNCHROTRON FACILITIES THAT WILL BE UPGRADED

Europe

MAX (Sweden) planning an upgraded new facility date unknown
MAX IV Project?

ESRF (Grenoble) Major upgrade is planned and funding is being negotiated.

North America

APS (Argonne National Laboratory) is planning an upgrade as an ERL.

FUTURE MAJOR NEUTRON FACILITIES

Asia/Pacific

JAERI-KEK Joint Facility for High-Intensity Proton Accelerators (J-PARC)
Website: http://j-parc.jp/en/message.html
Address: Japan Atomic Energy Agency
J-PARC Center
2-4 Shirane Shirakata, Tokai-mura
Naka-gun, Ibaraki 319-1195
Japan
Director: Shoji Nagamiya
Note: Successful completion is scheduled for 2008. JSNS is also part of this project.

PIK High-Flux Reactor, St. Petersburg, Russia (still under construction?)
Website: http://nrd.pnpi.spb.ru/facilities/menu_pik.html
Address: Petersburg Nuclear Physics Institute (PNPI)
Russian Academy of Sciences
Gatchina
Russia
Director: Valery V. Fedorov
Email: imshes@.pnpi.spb.ru

Chinese Advanced Research Reactor (CARR), Beijing, China
Website: http://www.ciae.ac.cn
Address: China Institute of Atomic Energy (CIAE)
P.O. Box 275-30
Beijing 102413
People's Republic of China
Start date: 2008

Chinese Spallation Neutron Source (CSNS), Beijing, China
Website: http://www.ciae.ac.cn
Address: China Institute of Atomic Energy (CIAE)
P.O. Box 275-30
Beijing 102413
People's Republic of China
Start date: 2011

Europe

European Spallation Source, Proposed but not yet funded

Website: http://essi.neutron-eu.net/essi
Address: Institut Laue-Langevin
BP 156
6, rue Jules Horowitz
38042 Grenoble Cedex 9
France
Director: Peter Tindemans

NEUTRON FACILITIES THAT WILL BE UPGRADED

Europe

Institut Laue-Langevin, Grenoble, France
Upgrades to be finished in 2008
Number of Instruments: 50 (no net increase)

ISIS Facility, Rutherford Appleton Lab, United Kingdom
Second target station under construction, to be finished in October 2008.
Number of Instruments: 30, seven of which are being added in expansion.

Appendix 4

Questionnaire on Access to Major International Facilities

Synchrotron and Neutron Facilities

The Committee on International Scientific Affairs (CISA) of the American Physical Society is undertaking a study of access to major international facilities in the fields of Particle Physics, Nuclear Physics and Condensed Matter and Materials Science taken broadly. In the latter field we are restricting ourselves to synchrotron and neutron facilities. The goal is to identify trends in the terms of access to major facilities. In the study CISA would like to include the major synchrotron and neutron scattering facilities, particularly those that have a well established user program with regular calls for proposals that are ranked by proposal review committees. As part of the study, we would be most grateful if you, as a major facility, would complete the questionnaire below that is intended for neutron and synchrotron sources. The findings of this study will be available to the international scientific community.

Please Note: Form fields in red are required.

Facility

Contact Email

1. Please classify your facility as
   ○ A national facility (supported financially predominantly by one nation).
   ○ A multinational facility (supported financially by more than one nation).
   ○ Other (please explain)
2. Does your facility receive proposals for experiments and are these proposals reviewed by Proposal Review Committees?
   ○ Yes ○ No
3. Please provide an estimate of your
   (1) No. of instruments listed in the proposal program

(2) Annual operating budget

4. Please provide data on the number of proposals submitted and accepted for years 1998 and 1999 and 2004 and 2005.

Year	**Proposals Submitted**	**Proposals Accepted**
1998		
1999		
2004		
2005		

5. Please provide data on number of users for the years 1998 and 1999 and 2004 and 2005.

Year	**Number of Users** (An individual counted once only per year)	**Number of Users Visits** (Multiple Visits per Year Counted)
1998		
1999		
2004		
2005		

If a different classification is used, please provide:

What percentage of users sends their samples for approved experiments by courier/mail and is not present at the experiment? %

6. What percent of the instruments at your facility are dedicated to (or supported by) specific groups (e.g. PRTs) that have a separate proposal program or no proposal program? %
7. On dedicated instruments, what percent of time is set aside for the dedicated group?
   % for group
   % available to general users via a proposal program
   % others

   If clarification or explanation is required, please provide:

8. Please list (1) the percentage of beam time devoted to experiments arising from accepted proposals and PRTs and (2) the percentage of beam time allocated for experiments initiated by facility scientists.

Year	**Percentage of beam time devoted to proposal program or PRT experiments**	**Percentage of beam time allocated to facility scientists**
1998	%	%
1999	%	%
2004	%	%
2005	%	%

9. Do the scientists and engineers that conduct experiments at your facility have a user organization? ○ Yes ○ No
10. Can you provide a contact name for this user organization?

11. Is use of the facility free of charge to the user for research that will be in the public domain?
    ○ Yes ○ No
12. Is the travel and accommodation of users from the nation (or the consortium of nations) supported by the facility? ○ Largely ○ Partially ○ Not at all
13. If the facility is multinational, is there an eventual balancing of experimental time allocated to users from nations within the consortium based on financial support of the facility by consortium members? ○ Yes ○ Some ○ No
14. Are proposals from applicants who are resident outside the country (or outside the consortium of countries) considered within the regular proposal program and reviewed by the same committees? ○ Yes ○ No
    If no, how are they considered?

    If yes, how are foreign (or non-consortium member) proposals considered?
    ○ with the same priority as others
    ○ a reasonable percentage is allocated to foreign users
    ○ collaboration with a scientist(s) from the nation (or consortium) is required
15. Do scientists from outside the nation (or consortium) serve on program committees?
    ○ Yes ○ No
16. Are statistics maintained of use of the facility by foreign (or non-consortium) applicants?
    ○ Yes ○ No
    If yes, could you please list the percentage of beam time used in which
    1. a foreign national is a team member %
    2. a foreign national is a team leader/PI/spokesperson %

    If you prefer to provide data in an alternate format, please provide a definition of the values provided:

17. Are there visa requirements or laboratory security requirements that foreign nationals must meet before access is permitted? ○ Yes ○ No
    If yes, please explain:

18. In the past 3 years have any national security or visa requirements limited foreign scientists in running experiments? ○ Yes ○ No
    If yes, can you estimate how many foreign scientists have been denied access to the facility in

the following years?

2003

2004

2005

19. Is there a trend toward multinational (consortium facilities) and away from national facilities in your country (or region)? ○ Yes ○ No

If yes, please elaborate:

Appendix 5

Questionnaire for User Groups and Societies on Access to Major International Facilities

Synchrotron and Neutron Facilities

The Committee on International Scientific Affairs (CISA) of the American Physical Society is undertaking a study of access to major international facilities in the fields of Particle Physics, Nuclear Physics and Condensed Matter and Materials Science taken broadly. In the latter field we are restricting ourselves to synchrotron and neutron facilities. The goal is to identify trends in the terms of access to major facilities. In the study CISA is including only major synchrotron and neutron scattering facilities that have a well established user program with regular calls for proposals that are ranked by proposal review committees. As part of the study, we would be most grateful if you, as representatives of users of the facilities, would complete the questionnaire below. The aim is to identify the goals of your society and those features that you find make a facility attractive to users. The findings of this study will be available to the international scientific community.

Please Note: Form fields in red are required.

User Group or Society Name ____________________

Contact Email ____________________

Please indicate whether your institution is a:

○ User Group

○ Society

○ Other

Explain:

Approximately how many members does your group/society have?

A) GOALS AND ACTIVITIES OF YOUR USER GROUP/SOCIETY

Please Rank from 4 to 1 (4 being the top score) the importance of the following goals and activities of your group/society:

1. Provides a feedback mechanism for users to the facility or facilities ○ 1 ○ 2 ○ 3 ○ 4
2. Holds regular meetings of members ○ 1 ○ 2 ○ 3 ○ 4
3. Actively lobbies on behalf of facilities and/or science ○ 1 ○ 2 ○ 3 ○ 4
4. Oversees proposal/experiment time allocation ○ 1 ○ 2 ○ 3 ○ 4
5. Reviews/provides oversight of facility on behalf of users ○ 1 ○ 2 ○ 3 ○ 4

B) PRACTICES OF USER FACILITIES

Please Rank from 4 to 1 (4 being the top score) the importance of the following features at a high quality user facility from the viewpoint of the group you represent:

1. Uniqueness of facility, source details and /or specific instruments ○ 1 ○ 2 ○ 3 ○ 4
2. Reliability of facility operation ○ 1 ○ 2 ○ 3 ○ 4
3. Availability of Sample environment equipment ○ 1 ○ 2 ○ 3 ○ 4
4. Good technical personnel and lab support available at the facility ○ 1 ○ 2 ○ 3 ○ 4
5. Reasonable success rate of submitted proposals ○ 1 ○ 2 ○ 3 ○ 4
6. Regular, well publicized call for proposals ○ 1 ○ 2 ○ 3 ○ 4
7. Accurate and complete information on access to the facility ○ 1 ○ 2 ○ 3 ○ 4
8. Equitable proposal review process with external reviewers ○ 1 ○ 2 ○ 3 ○ 4
9. Ease of travel to site ○ 1 ○ 2 ○ 3 ○ 4
10. Good accommodations on site for housing/food ○ 1 ○ 2 ○ 3 ○ 4
11. Other:

Appendix 6

SYNCHROTRON and NEUTRON FACILITIES that PARTICIPATED in the APS SURVEY

Synchrotron Facilities

Asia

Beijing Synchrotron Radiation Facility (BSRF)
Institute of High Energy Physics
Beijing
P.R. China

Pohang Accelerator Laboratory
San-31
Hyoja-dong
Pohang, Kyungbuk, 790-784
Korea

Super Photon Ring - 8 GeV (SPring8)
1-1-1 Kouto, Sayo-cho, Sayo-gun
Hyogo 679-5198
Japan

Europe

Berliner Elektronenspeicherring-Gesellschaft für Synchrotronstrahlung (BESSY)
BESSY GmbH, Albert-Einstein-Str.15
12489 Berlin
Germany

Elettra Synchrotron Light Source
Sincrotrone Trieste S.C.p.A. di interesse nazionale
Strada Statale 14
34012 Basovizza, Trieste
Italy

European Synchrotron Radiation Facility (ESRF)
6 Rue Jules Horowitz
BP 220

38043 Grenoble Cedex 9
France

Hamburger Synchrotronstrahlungslabor (HASYLAB) at DESY
DESY - HASYLAB
Notkestrasse 85
22607 Hamburg
Germany

MAX-lab, Lund University
Box 118
22100 Lund
Sweden

Siberian Synchrotron Radiation Centre (SSRC)
Lavrentyev av. 11
Budker INP
Novosibirsk 630090
Russia

Swiss Light Source (SLS)
Paul Scherrer Institut reception building
PSI West
CH-5232 Villigen PSI
Switzerland

Synchrotron Radiation Source (SRS)
CCLRC Daresbury Laboratory
Warrington, Cheshire
U.K. WA4 4AD

North America

Advanced Light Source (ALS)
Berkeley Lab
1 Cyclotron Rd
Berkeley, California 94720
USA

Advanced Photon Source (APS)
Argonne National Laboratory
9700 S. Cass Avenue
Argonne, Illinois 60439
USA

Cornell High Energy Synchrotron Source (CHESS)
200L Wilson Lab
Rt. 366 & Pine Tree Road
Ithaca, New York 14853
USA

National Synchrotron Light Source (NSLS)
Brookhaven National Laboratory
P.O. Box 5000, Bldg. 725B
Upton, New York 11973-5000
USA

Stanford Synchrotron Radiation Laboratory (SSRL)
Stanford Linear Accelerator Center
2575 Sand Hill Road
Menlo Park, California 94025
USA

South America

Laboratório Nacional de Luz Síncrotron (LNLS)
Caixa Postal 6192
CEP 13084-971
Campinas, SP
Brazil

Neutron Facilities

Asia

ISSP Neutron Science Laboratory
Institute for Solid State Physics
The University of Tokyo
106-1 Shirakata, Tokai, Ibaraki 319-1106
Japan

Europe

Frank Laboratory of Neutron Physics (FLNP)
Joint Institute for Nuclear Research
141980 Dubna, Moscow Region
The Russian Federation

Hahn-Meitner Institute (HMI)
Glienicker Str. 100
14109 Berlin
Germany

Institut Laue-Langevin (ILL)
6, rue Jules Horowitz
BP 156 - 38042 Grenoble Cedex 9
France

ISIS Pulsed Neutron & Muon Source
Rutherford Appleton Laboratory
Chilton
Didcot OX11 0QX
United Kingdom

Laboratoire Léon Brillouin (LLB)
CEA Saclay
Bâtiment 563
91191 Gif-sur-Yvette cedex
France

Paul Scherrer Institut (PSI)
5232 Villigen PSI
Switzerland

Jülich Reactor FRJ-2
Forschungszentrums Jülich GmbH (FZ Jülich) (FZJ-2)
Institut für Festkörperforschung
Postfach 19 13
52425 Jülich
Germany

(FRJ-2 Closed in Spring 2006)

St. Petersburg Nuclear Physics Institute
PNPI RAS
Gatchina, Leningrad district 188300
Russian Federation

North America

The Canadian Neutron Beam Centre (CNBC)
National Research Council Canada
Building 459, Station 18
Chalk River Laboratories
Chalk River, Ontario
Canada K0J 1J0

High Flux Isotope Reactor (HFIR)
HFIR Center for Neutron Scattering
Oak Ridge National Laboratory
P.O. Box 2008
Oak Ridge, Tennessee 37831
USA

Intense Pulsed Neutron Source (IPNS)
Argonne National Laboratory
9700 S. Cass Ave.
Argonne, Illinois 60439-4814
USA

Manuel Lujan Jr. Neutron Scattering Center at LANSCE
Los Alamos National Laboratory
P.O. Box 1663
Los Alamos, New Mexico 87545
USA

NIST Center for Neutron Research
Materials Science and Engineering Laboratory
National se of Standards and Technology (NIST)
100 Bureau Drive, MS 8562
Gaithersburg, Maryland 20899-8562
USA

User Groups and Societies that Responded to Questionnaire

U.S. User Groups

ALS: Gregory Denbeaux
Chair, Executive Committee, Advanced Light Source Users'
Organization
School of Nanosciences and Nanoengineering
University of Albany, SUNY
255 Fuller Road
Albany, NY 12203
gdenbeaux@uamail.albany.edu

LANSCE: Chris Gould, Chair
Executive Committee, Los Alamos Neutron Science Center Users'
Group
Physics Department
NC State University
Box 8202
Raleigh, NC 27695
chris_gould@ncsu.edu

IPNS: Thomas Koetzle, Chair
Executive Committee, Intense Pulsed Neutron Source Users'
Organization Tkoetzle@aol.com>, tkoetzle@anl.gov

NSLS: Peter Stephens
Chair, Executive Committee, National Synchrotron Light Source
Users'
Organization
Stony Brook University
Dept. of Physics & Astronomy
Stony Brook, NY 11794
pstephens@sunysb.edu

APS: Carol Thompson
Chair, Executive Committee, Advanced Photon Source Users'
Organization
Department of Physics
Northern Illinois University
DeKalb, IL 60115

cthompson@niu.edu

SNS & HFIR: Prof. Angus P. Wilkinson
Chair, Executive Committee, SNS HFIR User Group (SHUG)
Chemistry & Biochemistry
Georgia Institute of Technology
770 State Street
Atlanta, GA 30332-0400
angus.wilkinson@chemistry.gatech.edu

U.S. Societies

Robert Briber
Neutron Scattering Society of America
rbriber@umd.edu

European User Groups

ESRF: ESRF Users Organization
Prof. Marco Grioni (chairman)
Lausanne, Switzerland
marco.grioni@epfl.ch
user_org@esrf.fr

European Societies

Denmark: Danish Neutron Scattering Society
Kell Mortensen (Chair)
Risø National Laboratory
Danish Polymer Centre
Building 124, P.O. Box 49
Frederiksborgvej 399
DK-4000 Roskilde, Denmark
Email: **kell@life.ku.dk**

Europe: Peter Allenspach, President
The European Neutron Scattering Association (ENSA)
Peter.allenspach@psi.ch
http://neutron.neutron-eu.net/n_ensa/

France: Société Française de la Neutronique (SFN)
sfn@ill.fr
Francoise.Leclercq@hei.fr
Françoise Leclercq (CNRS-SC, Lille) Présidente

Germany: Komitee Forschung mit Neutronen (KFN)
http://www.physik.uni-kiel.de/kfn/
Prof. Dr. Helmut Schober (chairman)
Institut Max von Laue - Paul Langevin (ILL)
kfn@ill.fr

Sweden: Swedish Neutron Scattering Society
Adrian Rennie, Chairman

Dept of Physics
Uppsala University
Box 530
SE-751 21 Uppsala
Sweden
Adrian.Rennie@fysik.uu.se

Switzerland: Swiss Neutron Scattering Society
Paul Scherrer Institut
CH-5232 Villigen-PSI
Dr. P. Allenspach, President
peter.allenspach@psi.ch

Neutron Societies

Australia: Stewart Campbell, President (2005; 2006)
Australian Neutron Beam Users Group (ANBUG)
www.anbug.org
stewart.campbell@adfa.edu.au

OR

Craig Buckley, Vice-President (President-Elect 2007; 2008)
ANBUG
c.buckley@curtin.edu.au

Canada: Prof. Dominic Ryan, President, Canadian Institute for Neutron Scattering (CINS)
Physics Dept., McGill University
3600 University Street
Montreal, PQ
H3A 2T8
Tel 514-398-6534
Fax 514-398-6526
dominic@physics.mcgill.ca
gaulin@mcmaster.ca
http://www.cins.ca/

Korea: Professor Mahn-Won Kim, President
Professor Sung-Min Choi, Secretary
Korean Neutron Beam Users Association
mwkim@kaist.ac.kr
sungmin@kaist.ac.kr

Taiwan: Wen-Hsien Li, Representative of Taiwanese Society
Department of Physics
National Central University

Jung-Li 32054
Taiwan
whli@phy.ncu.edu.tw

Appendix 7

Meetings Held

1) Meeting with Officers of APS Divisions
   19 February 2005
   APS Unit Convocation
   College Park, Maryland

   Provided an introduction to and explanation of the study, its objectives, and time frame to the division officers and then held a roundtable discussion.

2) Meeting with Officers of APS Divisions
   23 March 2005
   APS March Meeting
   Los Angeles, California

   To solicit opinions, insights and suggestions from APS divisions regarding the study.

3) Wide consultation with directors and managers of facilities and executives of User Groups and Societies as well as scientists at facilities and those who conduct experiments at facilities throughout the world.

Appendix 8

Previous Reports on Major Synchrotron and Neutron Facilities

Condensed Matter and Materials Physics 2010: The Science of the World around Us.: National Academy Press, Washington D.C. 2007. Available online at <http://books.nap.edu/catalog.php?record_id=11967. >.

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Office of Science and Technology Policy (OSTP). 1999. Report of the OSTP Working Group on Structural Biology at Synchrotron Radiation Facilities. *Synchrotron Radiation for Macromolecular Crystallography.* Available online at <http://www.whitehouse.gov/ WH/EOP/OSTP/Science/html/cassman_rpt.html>.

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Basic Energy Sciences Advisory Committee (BESAC). 1997. *Synchrotron Radiation Sources and Science.* Washington, D.C.: U.S. Government Printing Office.

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Sciences, Purdue University, West Lafayette, IN 47907. An electronic version is available online at <http://www.ornl.gov/hgmis/ biosync>.

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Basic Energy Sciences Advisory Committee (BESAC). 1993. *Neutron Sources for America's Future, Report of the Basic Energy Sciences Advisory Committee Panel on Neutron Sources,* W. Kohn, ed. Washington, D.C.: U.S. Government Printing Office.

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Appendix 9

LIST OF ACRONYMS

ALS	Advanced Light Source
ANBUG	Australian Neutron Beam Users Group
ANL	Argonne National Laboratory (DOE)
ANS	Advanced Neutron Source
APS	Advanced Photon Source
BES	Basic Energy Sciences
BESAC	Basic Energy Sciences Advisory Committee
BESSY	Berliner Elektronenspeicherring-Gesellschaft für Synchrotronstrahlung
BNL	Brookhaven National Laboratory (DOE)
BSRF	Beijing Synchrotron Radiation Facility
CHESS 1	Cornell High Energy Synchrotron Source
CHRNS	Center for High Resolution Neutron Scattering
CINS	Canadian Institute for Neutron Scattering
CNBC	Canadian Neutron Beam Centre
DOC	Department of Commerce
DOE	Department of Energy
Elettra	Elettra Synchrotron Light Source
ENSA	European Neutron Scattering Association
ESF	European Science Foundation
ESRF	European Synchrotron Radiation Facility
FLNP	Frank Laboratory of Neutron Physics
HASYLAB	Hamburger Synchrotronstrahlungslabor
HFBR	High Flux Beam Reactor (Brookhaven National Laboratory)
HFIR	High Flux Isotope Reactor (Oak Ridge National Laboratory)
HMI	Hahn-Meitner Institute
ILL	Institut Laue-Langevin
IPNS	Intense Pulsed Neutron Source (Argonne National Laboratory)
ISIS	"Pulsed Spallation Neutron Source (Rutherford-Appleton Laboratory, UK)"
ISSP	ISSP Neutron Science Laboratory (Japan)
IWG	Interagency Working Group
Julich	Neutron Source at Julich
KFN	Komitee Forschung mit Neutronen
LANL	Los Alamos National Laboratory (DOE)
LANSCE	Los Alamos Neutron Science Center
LLB	"LLB, Saclay (France)"
LNLS	Laboratorio Nacional de Luz Sincrotron
LURE	Laboratoire pour l'Utilisation du Rayonnement Electromagnetique
Manuel Lujan	Manuel Lujan Jr. Neutron Scattering Center at LANS
MAX-lab	MAX-lab

MURR	University of Missouri Research Reactor
NBSR	Neutron Beam Split Core Reactor (NIST)
NCNR	NIST Center for Neutron Research
NIH	National Institutes of Health
NIST	National Institute of Standards and Technology
NIST	NIST Center for Neutron Research
NNSA	National Nuclear Security Administration (DOE)
NSF	National Science Foundation
NSLS	National Synchrotron Light Source
NSTC	National Science and Technology Council
OBER	Office of Biological and Environmental Research (DOE Office of Science)
OECD	Organization for Economic Cooperation and Development
ORNL	Oak Ridge National Laboratory (DOE)
OSTP	Office of Science and Technology Policy
Pohang	Pohang Accelerator Laboratory
PSI	Paul Scherrer Institut, Villigen, Switzerland
SANS	Small Angle Neutron Scattering
SFN	Societe Francaise de la Neutronique
SHUG	SNS and HFIR User Group
Siberian	Siberian Synchrotron and Terahertz Radiation Center
SINQ	Swiss spallation neutron source at the Paul Scherrer Institut
SLS	Swiss Light Source at the Paul Scherrer Institut
SNS	Spallation Neutron Source (Oak Ridge National Laboratory)
Spring8	Super Photon Ring - 8 GeV
SRS	Synchrotron Radiation Source
SSRL	Stanford Synchrotron Radiation Laboratory
St. Petersburg 1	St. Petersburg Nuclear Physics Institute (Part 1)
St. Petersburg 2	St. Petersburg Nuclear Physics Institute (Part 2)

Advanced Photon Source Users' Organization
ALS Users' Executive Committee
Danish Neutron Scattering Society
ESRF Users Organization
Intense Pulsed Neutron Source Users' Organization
Korea
Los Alamos Neutron Science Center Users' Group
National Synchrotron Light Source: Users' Executive
Swedish Neutron Scattering Society
Swiss Neutron Scattering Society
Taiwan Neutron Society