

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.