NSF Advisory Panel on Light Source Facilities

Background

There are currently six federally-supported light source facilities in the US, as follows (dates show year of commissioning)[1]:

- Stanford Synchrotron Radiation Laboratory (SSRL) at the Stanford Linear Accelerator Center (1974)
- Cornell High Energy Synchrotron Source (CHESS) at Cornell University (1980)
- National Synchrotron Light Source (NSLS) at Brookhaven National Laboratory (1982)
- Synchrotron Radiation Center (SRC) at the University of Wisconsin (1985)
- Advanced Light Source (ALS) at Lawrence Berkeley National Laboratory (1993)
- Advanced Photon Source (APS) at Argonne National Laboratory (1996)

The Department of Energy (DOE) Office of Basic Energy Sciences supports the four facilities located at national laboratories; NSF (through the Division of Materials Research) is the steward for the two facilities located at universities. These six facilities support an extremely broad range of 'small science' experiments involving users from a wide variety of disciplines, including physics, chemistry, materials science, biological sciences, many branches of engineering, earth sciences, and even art conservation.

In addition to major investments in construction, operation, and instrument development made by the steward agencies, several partner agencies - including NIH, DARPA, and NSF – have made significant contributions to instrumentation and beamline development at various light sources. For example, in 2004 NSF's Division of Materials Research (DMR) initiated support of Mid-Scale Instrumentation Projects as part of the Instrumentation for Materials Research Program. The IMR-MIP Program supports both conceptual engineering design and construction projects for instruments located at US user facilities and costing between $2M and $20M. The steward agency takes responsibility for the operation of the instrument after construction.

The two NSF-supported synchrotron facilities have been in operation for more than 20 years. In the relatively near term it appears clear that they must be (1) phased out, (2) significantly upgraded, or (3) superseded by or transitioned into state-of-the art facilities. Upgrading these facilities or replacing them with new state-of-the-art facilities will require a significant capital expenditure, and subsequently a substantial increase over current funding levels for operations and management.

In 1999 the National Research Council published a report on "Cooperative Stewardship: Managing the Nation's Multidisciplinary User Facilities for Research with Synchrotron Radiation, Neutrons, and High Magnetic Fields". The report strongly endorses a cooperative stewardship model for managing such facilities, stating that:

[1] A complete list of current light source facilities worldwide is available at http://www.lightsources.org/cms/?pid=1000098

> There are two components to multidisciplinary user facilities: the core of the facility and the individual experimental units, and this division leads to a natural division of management responsibilities. Responsibility for the core components should reside with the steward. Responsibility for the experimental units, including the training and support of new users, could also reside with the steward; alternatively, it could reside with the sponsors of the experimental units, the partners, which could be either other government agencies or organizations in the private sector.

The Department of Energy is likely to remain the principal source of support for major light sources in the U.S. for the foreseeable future. Recent workshops, however, have also examined the scientific case for major new light source facilities that might in some circumstances be university-based.[2,3,4] NSF's Directorate for Mathematical and Physical Sciences (MPS) currently supports a 4-year award to Cornell University for conceptual and engineering design of an Energy Recovery Linac, which represents one possible approach to state-of-the-art light sources.

Construction costs for such facilities are estimated to be several hundred million dollars, bringing them under the aegis of NSF's Major Research Equipment and Facility Construction account. The MREFC account was established to support large construction and/or acquisition projects with costs comparable to annual NSF Division budgets; interim and final approval of each project is the responsibility of the National Science Board (NSB)[5].

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[2] ERL X-ray Science Workshops, Cornell University, May 2006. http://erl.chess.cornell.edu/gatherings/erl%20workshop/index.htm.

[3] "New Scientific Opportunities with VUV and Soft X-ray Free Electron Lasers", workshop report, Synchrotron Radiation Center, University of Wisconsin, Madison, October 2006. http://www.src.wisc.edu/

[4] CMMP-2010 Facilities Workshop, National Research Council, Irvine, CA, January 28-29, 2007. http://www7.nationalacademies.org/bpa/CMMP2010_Facilities_Workshop.html

[5] The process and criteria for establishing priorities for MREFC projects are described in detail in *A Joint National Science Board – National Science Foundation Management Report: Setting Priorities for Large Research and Facilities Projects Supported by the National Science Foundation* (NSB-05-77, September 2005) http://www.nsf.gov/pubs/2005/nsb0577/index.jsp.
MREFC projects under consideration must undergo a multi-phase internal and external review and approval process. This includes a review by the internal NSF MREFC Panel, which makes recommendations to the NSF Director with attention to criteria such as scientific merit, importance, readiness, and cost-benefit. An overarching cross-disciplinary context for assessing the value of a proposed facility in comparison to other investments is presented annually by NSF to the NSB. The *Facility Plan* combines in one document a report on major facilities under construction and in various stages of development, together with a discussion of the science objectives and opportunities that provide the context and compelling need for each facility. The *Facility Plan*, updated regularly and made public, provides a comprehensive exposition of the needs and plans to inform decisions, and serves as an important vehicle for communicating with the research communities. See NSF-07-22 at http://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf0722&org=NSF.
NSF MREFC projects currently approved or under construction are listed in the *MREFC Funding Table* (page 8 below). Detailed descriptions of each project are given in the budget request and the *Facility Plan.*

While construction funding for major facilities is now provided from the MREFC account, initial planning costs and subsequent operational costs are assumed by the appropriate Research and Related Activities Directorate(s). Existing MPS user facilities and their operating costs are listed in the *MPS Facilities Funding Table* in the NSF Budget Request for FY 2008).[6] The list includes smaller facilities constructed using Directorate or Division funds.

The operational costs for a future light source facility will be substantially higher than current operating costs for the NSF synchrotron facilities; these future costs are likely to be $30 - $50 million per year or more. The NSF organization with lead responsibility for management and oversight of such a facility is likely to be the Division of Materials Research within MPS. However, broad, cross-disciplinary partnership and support representative of the diverse user communities involved will be essential to ensure responsible long-term stewardship for facilities of this scope and magnitude.

MPS Committee of Visitors reports and the NSB have stated the importance of maintaining an appropriate balance among funding modes. DMR Committees of Visitors in particular have emphasized the need for balanced support for individual investigators and small groups, centers, and user facilities.[7] In view of the constraints of cost, program balance, broad cross-disciplinarity, and the national needs for future research and education related to high-intensity light sources, a careful assessment of NSF's potential role in support of such facilities is essential. Expert guidance from the relevant science and engineering communities represented by this Panel will be a critical aspect of the assessment.

[6] NSF budget request for FY 2008. http://www.nsf.gov/about/budget/fy2008/toc.jsp.
[7] Committee of Visitors Report, 2005, NSF Division of Materials Research. http://www.nsf.gov/od/oia/activities/cov/mps/2005/DMRcov.pdf

Charge to the Panel

The Panel is charged to provide guidance to the Directorate for Mathematical and Physical Sciences regarding future NSF stewardship and/or partnership in support of coherent light source facilities and instrumentation. Specifically:

- What is the current view of opportunities for future research using major advanced light source facilities, and what facilities are envisioned to carry out such research in the U.S.?
- What does the Panel see as the most effective role for the NSF in helping to develop, construct, instrument and operate such facilities?
- Do university-based light sources now under discussion in the community (for example, a soft X-Ray Free Electron Laser and/or an Energy Recovery Linac) have a critical role to play in realizing the opportunities?

The Panel's guidance is requested in the context of:

1. Science drivers in research fields and subfields likely to make use of major light source facilities
2. The potential for interagency, private sector, and international partnerships
3. Department of Energy and other federal agency plans for advanced light sources in the US, and new facilities planned or under construction worldwide
4. Education and future workforce needs
5. The multidisciplinary nature of the anticipated user communities
6. Budget outlook and balance for NSF, MPS, and DMR
7. NSF's responsibility to maintain appropriate balance at all levels among funding modes, including resources for individual investigators, groups, centers, and instrumentation, as well as major user facilities.

Subject to subsequent proposal review and approval, possible outcomes may include future NSF support for construction and stewardship of one or more major new light source facilities; NSF support for conceptual development and engineering design projects related to future light sources; NSF partnership through support of instrument development projects at national laboratories stewarded by the Department of Energy; or some combination of these approaches.

Reporting Mechanism

The Advisory Panel on Light Source Facilities will report to the MPS Advisory Committee through the MPSAC Chair. A member of the Advisory Committee will serve *ex officio* as MPSAC Liaison on the Panel.

Resource Materials

- *Cooperative Stewardship*; Commission on Physical Sciences, Mathematics and Applications; Committee on Developing a Federal Materials Strategy, NRC 1999.
  http://www.nap.edu/catalog.php?record_id=9705
- *Advanced Research Instrumentation and Facilities*; Committee on Science, Engineering and Public Policy; Committee on Advanced Research Instrumentation, NAS 2005.
  http://books.nap.edu/catalog.php?record_id=11520
- *Setting Priorities for Large Research Facilities Projects Supported by the National Science Foundation*, NAS 2004.
  http://books.nap.edu/catalog.php?record_id=10895
- *Setting Priorities for Large Research and Facilities Projects Supported by the National Science Foundation* (NSB-05-77, September 2005; response to the NAS Report).
  http://www.nsf.gov/pubs/2005/nsb0577/index.jsp.
- *Science and Engineering Infrastructure for the 21st Century: The Role of the National Science Foundation*, NSB 02-190, National Science Board 2003.
  http://www.nsf.gov/nsb/documents/2002/nsb02190/nsb02190.pdf
- *Facility Plan* (NSF-07-22)
  http://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf0722&org=NSF.
- *Midsize Facilities: The Infrastructure for Materials Research*; NRC 2006.
  http://www.nap.edu/books/0309097029/html
- Facilities Workshop Presentations, CMMP-2010 Committee, NAS Board on Physics and Astronomy, January 28-29 2007.
  http://www7.nationalacademies.org/bpa/
- *European Roadmap for Research Infrastructures*; European Strategy Forum on Research Infrastructures, European Commission 2006.
  http://cordis.europa.eu/esfri/
- NSF, MPS and DMR budget request data for FY 2008.
  http://www.nsf.gov/about/budget/fy2008/toc.jsp).