Statement of

Dr. Steven B. Dierker
Associate Laboratory Director for Light Sources
National Synchrotron Light Source II Project Director
Brookhaven National Laboratory

Before the
Subcommittee on Energy and Environment
Committee on Science and Technology
U.S. House of Representatives

Regarding the Basic Energy Sciences Program Reauthorization
September 10, 2008

Thank you Mr. Chairman, Ranking Member Inglis, and Members of the Committee for the opportunity to appear before you to provide testimony on the Basic Energy Sciences (BES) Program in the Department of Energy's (DOE's) Office of Science (SC). I have worked in industry, in academia, and, since 2001, in the DOE national laboratory system, first as Director of the National Synchrotron Light Source and most recently as the Associate Laboratory Director for Light Sources and the Project Director for the National Synchrotron Light Source II Project at Brookhaven National Laboratory. I am pleased to share with you my perspectives on the synchrotron radiation light sources operated by BES.

Synchrotron radiation light sources

Under BES leadership, the four BES light source facilities, the National Synchrotron Light Source (NSLS) at Brookhaven National Laboratory (BNL), the Stanford Synchrotron Radiation Laboratory (SSRL) at the Stanford Linear Accelerator Center (SLAC), the Advanced Light Source (ALS) at Lawrence Berkeley National Laboratory (LBNL), and the Advanced Photon Source (APS) at Argonne National Laboratory (ANL), have thrived and flourished. They have become one of the great success stories of the past 25 years. Created by a handful of pioneering physicists, they are now used by more than 8,000 academic, industrial, and government researchers annually from all disciplines and from every state in the U.S. as well as foreign countries.

My own experience is with the National Synchrotron Light Source, which is representative of the other BES light sources. With close to 1,000 publications per year, the NSLS is one of the most prolific scientific facilities in the world. Each year, it attracts about 2,200 scientists from 350 universities and 90 companies to conduct research at 65 beamlines in such diverse fields as biology, physics, chemistry, geology, medicine, and environmental and materials sciences.

The BES light sources give researchers unique capabilities for carrying out basic long term research that is essential for the development of future energy technologies. For example, using the BES light sources, scientists:

- have studied catalysts that could help improve the performance of hydrogen-powered fuel cells, a key component of future clean-car technologies;
- have studied electrolytes in lithium-ion batteries with the aim of improving their performance;
- have studied the properties of high-temperature superconductors, materials that conduct electricity with almost zero resistance and promise high efficiency transmission of power for the electric grid; and
- have studied flame chemistry and combustion, leading to more efficient designs for fuel spray nozzles.

These are only a few examples of the wide-ranging high-impact fundamental and applied research made possible by the synchrotron radiation light sources.

User Access and Facility Management

The goal in operating a major light source facility is to enable world-class science and technology and to operate with maximum effectiveness for all users. Large numbers of users now want to use a very limited number of beamlines, a situation distinctly different from that even 20 years ago. Many beamlines are oversubscribed and cannot meet user demand for beamtime. The light sources represent a scarce national resource. As a result of these trends, the BES light source facilities are taking a greater role in constructing and operating the beamlines and instruments in order to better accommodate user needs and to ensure stable, reliable operations.

In selecting the beamlines to be constructed at the light source facilities, facility management needs to ensure that the appropriate capabilities are present at the facility so that it is as productive as possible. Facility planning needs to prioritize among competing demands and strike the appropriate balance between different scientific communities. All key stakeholders, including the user community, funding agencies, and facility management, are actively engaged in facility planning through workshops, whitepapers, advisory committee meetings, and other means. This inclusiveness in planning is a hallmark of the DOE selection process and is a key contributor to DOE's successful management of the light source facilities.

BES light sources routinely operate about 5,500 hours per year, i.e., 24 hours per day for about 230 days, with the remainder required for necessary maintenance and upgrades. The accelerators at the heart of the light sources operate very reliably, generally delivering 95% or more of their scheduled operating hours. However, not all of the beamlines are operating at their full potential. It is critically important that today's facilities be provided full support for operations to meet the ever increasing demand for synchrotron radiation facilities. Support for research and development for new instrumentation and detectors is equally important to take maximum advantage of today's facilities.

Advances in Synchrotron Light Sources

The utility of today's light sources has been greatly extended by technological progress in many areas that has resulted in spectacular gains in source performance. Nevertheless, there is a critical need for even more advanced and powerful storage ring based light sources.

The economic and energy security of the United States requires that we make major advances in developing alternative energy and pollution control technologies – such as the use of hydrogen as an energy carrier; the widespread, economical use of solar energy; or the development of the next generation of nuclear power systems. Achieving this will require basic research leading to scientific breakthroughs in developing new materials with previously unimagined properties. Examples include catalysts that can split water with sunlight for hydrogen production, materials that can reversibly store large quantities of hydrogen, materials for efficient power transmission lines, materials for solid state lighting with 50 percent of present power consumption, and materials for reactor containment vessels that can withstand fast-neutron damage and high temperatures. The National Nanoscience Initiative is predicated on the promise of exploiting the remarkable changes in properties of materials when structured on the nanoscale to develop new materials with enhanced properties.

To realize this promise, it is essential that we develop new synchrotron radiation tools that will allow the characterization of the atomic and electronic structure, the chemical composition, and the magnetic properties of materials with nanoscale resolution, capabilities that are beyond today's light sources. In order to fill this capability gap and to further the accomplishment of its mission, the BES program plans to construct the National Synchrotron Light Source II (NSLS-II) facility as a replacement for NSLS. NSLS-II will enable the study of material properties and functions, particularly materials at the nanoscale, at a level of detail and precision never before possible. No other synchrotron light source worldwide will have the beam characteristics and advanced instrumentation of NSLS-II. It will be part of a new era of science that is key to America's competiveness, where material properties can be sufficiently well understood to be predictable and ultimately tailored to specific applications.

Construction Project Management

The BES program has an outstanding track record, successfully constructing some of the largest and most productive facilities within the Office of Science. The so-called "Lehman Reviews" ensure that the lessons-learned within SC inform the plans for new facilities. The NSLS-II facility construction plans were subjected to a rigorous series of these SC Lehman reviews and the resulting cost, schedule, and technical baseline that was approved by the Deputy Secretary of Energy is robust, establishing realistic goals for the construction of the facility.

As the NSLS-II Project Director, I have the opportunity to work closely with the BES program management and the DOE Brookhaven Site Office as part of an Integrated Project Team that shares the common goal of constructing NSLS-II on schedule and within the approved budget. It is a pleasure to work with a DOE team that has such an excellent track record and understanding of the challenges encountered in the construction of new facilities.

In what follows, I provide additional details on these topics.

Synchrotron radiation light sources

Synchrotron radiation light sources are large and complex facilities for accelerating electrons to nearly the speed of light and then storing them in a circular orbit using a storage ring consisting of hundreds of large magnets and other components. At controlled points around the storage ring, the electrons are made to emit high intensity narrow beams of light at wavelengths that span the range from the infrared, through the visible, to soft, and hard x-rays. This synchrotron radiation light is a natural phenomena, similar to the starlight we see at night, but a synchrotron radiation light source produces much more intense and narrow beams and at many locations around the storage ring. These light beams are transported down “beamlines” to experiment stations containing sophisticated apparatus that allows researchers to use the light to study the properties of materials.

The information obtained in experiments carried out at synchrotron light sources often cannot be obtained any other way. A synchrotron radiation light source may have 60 or more of these experimental beamlines, all operating simultaneously. The facility can thus host a large number of research groups, all carrying out different experiments at the same time.

The wealth and variety of experimental techniques available at synchrotrons is characterized by the very wide photon energy range they can offer, from the far infrared to the very hard x-ray. Most techniques, and the instruments that enable these techniques to be performed, are associated with a particular photon energy range. Thus, the wide energy range offered to users is served by a wide variety of experimental techniques. While each of the beamlines is different and complementary, they can be grouped into the following four major categories:

Diffraction and scattering techniques make use of the patterns of light produced when x-rays are deflected by the closely spaced atoms in solids and are commonly used to determine the structures of fully ordered or partially ordered materials, from ferroelectrics for use in electronics to new superconductors for possible power applications.

Macromolecular crystallography is the most powerful method for the determination of the three-dimensional structure of large biological molecules (macromolecules). This technique can be used to design therapeutic drugs and determine the structure and mechanisms of enzyme, nucleic acids, viruses, and numerous other molecules in order understand life processes and how to better diagnose and treat disease.

Imaging techniques produce pictures with fine spatial resolution of the sample being studied, for use in research ranging from visualizing plaque formation in Alzheimer's disease patients to the environmental analysis of soils.

Spectroscopy is used to study the energies of particles that are emitted or absorbed by samples that are exposed to a light-source beam. It provides unique information on the composition of a sample and the chemical nature of the bonding. Experiments include measuring the concentration and chemical nature of impurities in systems, from soils to silicon solar cells, or measuring the excitations of magnetic systems to develop better performing nano-magnetic memory devices.

User Access and Facility Management

Users of the facilities include academic, industrial, and government scientists and engineers. The results of the vast majority of user research are made available in the public domain by publication in the open literature. There is also a limited need for access to carry out proprietary research that utilizes these unique facilities to benefit the national economy. Proprietary research is the only mode of user access for which there is a charge for beam time.

The facilities have adopted policies for user access that are designed to achieve the following objectives:

- ensure open and fair access by the scientific community at large;
- sustain the highest standards of scientific and technical excellence; and
- respond and adapt to varying user needs and funding realities

The key to delivery of outstanding science and technology is rigorous peer review that is fair, clear, expedient and sensitive to the needs of users. Various external independent advisory committees play key roles in providing this.

Users access the facilities by submitting proposals as either General Users or as Partner Users. General Users are individuals or groups who need access to beam time to carry out their research using existing beamlines. They typically only supply samples, but can also provide custom instrumentation or endstations for the duration of their experiments. General Users apply for access by submitting a scientific proposal that is evaluated by an independent review panel. The amount of beam time allocated to the proposal depends on the rating of the proposal relative to other proposals requesting beam time and on beam time availability.

In some cases, users have a need to obtain experimental results on an expedited schedule. This is often the case when the synchrotron measurement can be done in a short amount of time and is only one step of an overall experimental program. Examples include high throughput measurement of properties of materials grown using combinatorial synthesis techniques, screening of protein molecules to identify large, well diffracting crystals, or the solution of many time critical analytical problems studied in industry. To serve this need, “Rapid Access” proposals receive an expedited review and can usually be scheduled for beamtime within a week or two.

Partner Users are individuals or groups who carry out research at beamlines and also enhance the beamline capabilities and/or contribute to its operation. Partner Users typically develop instrumentation in some manner, either bringing external financial and/or intellectual capital into the evolution of the beamlines, or by making an external contribution to the operation of the beamlines. Partner User contributions have to be made available to the General Users and so benefit them as well as the facility. To encourage involvement and in exchange for making these contributions available to General Users and the facility, Partner Users may be recognized for their investments by receiving a specified percentage of beam time on one or more beamlines for a limited period, typically several years, with the possibility of renewal.

Various models have emerged for allocation of beamline resources, i.e., for determining who specifies, builds, owns, operates, maintains, and uses the beamlines. Beamline allocation models range from Facility Owned and Operated Beamlines (FOOBs) that are built, owned, and operated by the facility for general users to Participating Research Teams (PRTs) and Cooperative Access Teams (CATs) in which consortia of outside users build, own, and operate the beamlines. PRTs and CATs are a special case of a Partner User group in which the PRT/CAT has brought in external funds to independently and wholly build, maintain, staff and operate a beamline. The PRT/CAT is required to provide some fraction of beamtime – typically 25% – to General Users and to provide training and assistance to General Users who are allocated beam time on their beamline. In exchange, the PRT has complete control over the beamline and manages its scientific program for the remaining available beam time of up to 75% for a renewable term of typically three years.

Many facilities have a mixture of FOOBs, PRTs, and/or CATs. The BES light source facilities are currently evolving their access models to emphasize FOOBs in most cases in order to better accommodate user needs and to ensure stable, reliable operations.

Construction Project Management

The DOE has extensive experience with effectively managing large scale construction projects to deliver the mission need safely, on time, and within budget. The requirements for projects to achieve this have been stated in the DOE Order 413.3A, *Program and Project Management for the Acquisition of Capital Assets*, and its implementation manual, DOE M 413.3-1, *Project Management for the Acquisition of Capital Assets*. All projects costing more than $20M are carried out in accord with these requirements.

DOE Order 413.3A defines five Critical Decisions, or "CDs" – formal determinations or decision points in a project lifecycle that allow the project to proceed to the next phase and commit resources. Each decision constitutes a work authorization for a specific phase of the project. The Deputy Secretary of Energy serves as the Secretarial Acquisition Executive (SAE) for the Department and approves site selection and Critical Decisions for Major System Project.

CD-0, Approve Mission Need, authorizes preparation of a Conceptual Design Report, Acquisition Strategy, Risk Management Assessment, and Safety Documentation. CD-1, Approve Alternative Selection and Cost Range, authorizes the expenditure of Project Engineering and Design funds to proceed with Title I (preliminary) and Title II (final) design. CD-2, Approve Performance Baseline, establishes the technical, schedule, and cost performance baseline for the project. CD-3, Approve Start of Construction, authorizes the project to start full-scale construction. CD-4, Approve Project Completion, is accomplished when the project scope has been delivered and demonstrated to be functioning properly and safely and the facility is ready to begin operations.

An essential element of project management systems is the control of changes to the performance baseline. Changes to project execution are evaluated in terms of baseline impacts. Through a graduated hierarchy of change control authority, appropriate levels of management become involved in decisions regarding project changes.

Real-time monitoring of a project occurs through established mechanisms among project participants. Progress reviews of the project are conducted by SC, typically at semiannual intervals, with results of these reviews provided to the Under Secretary for Science. Quarterly Progress Reviews are conducted between the Under Secretary for Science and the Federal Project Director. Formal project reporting, including monthly data submissions into the DOE Project Assessment and Reporting System (PARS), is in effect for the duration of a construction project. The monthly PARS report also serves as the basis for the NSLS-II Project's input to the Office of Engineering and Construction Management (OECM) Monthly Project Status report to the Deputy Secretary of Energy.

The safety and security of all staff, guests, contractors, vendors, and the environment is a primary priority in construction projects. It is expected that all staff and contractors will plan, manage, and execute their respective duties consistent with the requirements of the tenets of Integrated Safety Management to ensure that the facility is designed, constructed, and operated in a safe and environmentally sound manner to ensure the protection of the workers, the public, and the environment.

Concluding Remarks

Thank you, Mr. Chairman, for providing this opportunity to discuss the Basic Energy Sciences program. This concludes my testimony, and I would be pleased to answer any questions you might have.