Statement of

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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 most heavily used type of the major scientific user facilities constructed and operated by BES, i.e., the synchrotron radiation light sources.

Synchrotron radiation light sources

My own experience is with the National Synchrotron Light Source and I will describe its programs as representative of those of any of the major synchrotron light source facilities operated by BES. With close to 1,000 publications per year, the NSLS is one of the most prolific scientific facilities in the world. Each year, this user facility attracts about 2,200 scientists from more than 400 universities and 65 companies to conduct research at 65 beamlines in such diverse fields as biology, physics, chemistry, geology, medicine, and environmental and materials sciences. These scientists come from throughout the U.S. as well as foreign countries, although two-thirds of the users come from the Northeastern U.S., indicative of the regional character of these facilities.

Promoting collaboration between interdisciplinary groups across the country, the NSLS gives researchers unique capabilities for conducting high-impact energy research. For example, scientists have used the NSLS to probe electrolytes in lithium-ion batteries with the aim of improving their performance; they have studied catalysts that could help improve the performance of fuel cells, with the goal of producing "clean" hydrogen for fuel cell reactions; they have probed the properties of high-temperature superconductors, materials that conduct electricity with almost zero resistance and promise high efficiency power transmision; they have investigated the role of metal catalysts in hydrogen storage, toward the goal of a hydrogen economy; and they have developed a new way to use x-rays to study carbon nanotubes, tiny cylindrical carbon molecules with exceptional strength, conductivity, and heat resistance. Although these examples reflect work at the NSLS, similar kinds of high impact research in many disciplines take place at all of the BES light source facilities

Under BES leadership, the four BES light source facilities have thrived and flourished. They have become one of the great success stories of the past 25 years. Once the province of a few hundred specialists, mostly physicist, they are now used by more than 8,000 researchers annually from all disciplines and with support from DOE, NSF, NIH, EPA, USDA, other federal agencies, and foreign countries. They come from universities, industry (both large and small), and government laboratories, and from every state in the U.S.

User Access and Facility Management

The goal in operating a major light source facility is to enable world-class science and to operate with maximal effectiveness for all users. Many users want access to multiple instruments and end stations in order to carry out a program of studies. Some want regular access over a period of years. 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 will be present at the facility in order that it is as scientifically productive as possible. This is especially challenging given the high user demand for access to the facilities. Facility planning needs to:

- prioritize among competing demands, e.g., new ideas versus continuation of existing communities;
- strike the appropriate balance between different scientific communities; and
- balance the need for experiments that have high scientific impact but might serve only a few users against the need for high throughput experiments that serve a large number of users and are often particularly important to technology development and industry.

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.

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 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 and achieve economic and energy independence, it is essential that we have the world's most advanced scientific tools. Although synchrotron radiation is unmatched in its ability to determine the physical, chemical, electronic, and magnetic properties of materials, it is currently impossible to do so with nanometer (nm) spatial resolution and 0.1 millielectron volt (meV) energy resolution. There is a critical need to 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.

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 fill the gap by enabling 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 these beam characteristics and advanced instrumentation.

Construction Project Management

BES 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.

Typically, synchrotron light sources are scheduled to 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 synchrotron light sources operate very reliably, generally delivering 95% or more of their scheduled operating hours.

BES operates four major synchrotron 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).

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. For example, SSRL is overwhelmingly FOOBs with some PRTs. The APS started operations with primarily CATs and has evolved to a mixture of CATs and FOOBs as the facility has matured. These models served the community well during the years of rapid growth in usage of the synchrotron light sources. They enabled a large number of users from diverse communities to become regular users of the light sources. However, due to the trends noted earlier, the BES light source facilities are evolving their access models to emphasize FOOBs 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*. The NSLS-II Project is being carried out in accord with these requirements, as are all DOE construction projects costing more than $20M.

DOE Order 413.3A defines five Critical Decisions – 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 the NSLS-II Project, a Major System

Project. The Director of the Office of Science serves as the Program Secretarial Officer (PSO) and approves the Mission Need Statement and the Acquisition Strategy.

The Director of the Office of Science approved the Mission Need Statement for NSLS-II on July 19, 2005 and the SAE approved **CD-0, Approve Mission Need**, on August 25, 2005. Approval of CD-0 authorized preparation of a Conceptual Design Report, Acquisition Strategy, Risk Management Assessment, and Safety Documentation.

The **Acquisition Strategy** (AS) for NSLS-II determined that having Brookhaven Science Associates, the BNL Management and Operating (M&O) contractor, build NSLS-II at BNL delivers the greatest mission capability soonest, at the lowest cost and best value, and with minimum disruption to existing scientific capabilities. The NSLS-II Project makes use of existing BNL experienced staff and facilities and activities, such as the construction of conventional facilities, will be accomplished to the extent feasible using fixed-priced incentivized subcontracts with selection based on best value, price, and other factors. The AS for NSLS-II was approved by the Under Secretary for Science on May 10, 2007.

Approval of **CD-1, Approve Alternative Selection and Cost Range,** authorized the expenditure of Project Engineering and Design funds to proceed with Title I (preliminary) and Title II (final) design. CD-1 was approved by the SAE on July 12, 2007 and determined that the project will be located at Brookhaven National Laboratory.

Approval of **CD-2, Approve Performance Baseline,** established the technical, schedule, and cost performance baseline for the project. CD-2 was approved by the SAE on January 18, 2008, with a Total Project Cost (TPC) of $912M.

Approval of **CD-3, Approve Start of Construction,** authorizes the project to start full-scale construction of NSLS-II. Approval of CD-3 by the SAE is anticipated in the 1st Qtr, FY09.

Project completion (**CD-4, Approve Project Completion**) will be accomplished when the scope defined in the Work Breakdown Structure (WBS) has been delivered and demonstrated to be functioning properly and safely. The WBS contains a complete definition of the project's scope and forms the basis for planning, executing, and controlling project activities. Prior to CD-4, a period of commissioning and performance testing for NSLS-II will be completed as technical systems and facilities are installed. At project completion, the project and DOE managers will recommend facility acceptance and approval of CD-4. Approval of CD-4 by the SAE is scheduled for the 3rd Qtr, FY15.

An essential element of project management systems is the control of changes to the performance baseline and the implementation approach. The NSLS-II Project Execution Plan (PEP) establishes the project baseline (technical, schedule, and cost) against which project execution is measured. 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. The PEP also serves as the primary reference document for all levels of the project team and the primary source document for technical requirements, policies, and procedures for resource allocation, procurement, budgeting and finance, work authorization, management, reporting, reviews, and evaluations.

Real-time monitoring of the NSLS-II 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 the 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. In addition, the Federal Project Director and the NSLS-II Project Director conduct monthly status meetings as a regular, comprehensive assessment of the NSLS-II Project status.

Peer and independent reviews are an excellent management tool and serve to verify the NSLS-II Project's mission, organization, development, baseline and progress. External Independent Reviews and Independent Project Reviews are performed by OECM and SC's Office of Project Assessment in support of approval of CD-2 and CD-3.

Actual cost of work performed, using accrued costs, and actual progress (earned value) on the NSLS-II Project are collected using a project-wide reporting and controls system, with routine monthly reporting to DOE. Project performance data is tracked against the baseline, variance analyses performed, needed corrective actions identified, and future risks identified. The implementation of this process is in accord with the BNL Earned Value Management System (EVMS), which is compliant with ANSI Standard ASNI/EIA-748-A-1998.

Risk is always a concern in the acquisition of capital assets, especially in complex, technically challenging, and costly projects. Because risk is inherent in such projects, the acquisition process is designed to allow risks to be controlled from conception to delivery. The key to successful risk management is early planning, unbiased assessments, and aggressive execution. Good planning enables an organized, comprehensive, and iterative approach for identifying and assessing the risks and handling options necessary to successfully carry out the acquisition of a capital asset. Risk assessment and identification is performed as early as possible in the life cycle to ensure that critical technical, scope, schedule, and cost risks are identified and/or addressed as part of the program and project planning, execution, and budget activities. Management continuously updates acquisition and risk assessments and modifies management strategies accordingly.

Risks anticipated for the NSLS-II Project are analyzed and managed in accordance with the methods identified in the DOE M 413.3A. The *NSLS-II Risk Management Plan* identifies the scope of the project's risks and delineates the methodology that is used to identify, quantify, and assess risks. It identifies the controls and processes used to identify and mitigate areas of cost, scope, schedule, and technical risk that occur during project planning and implementation.

The safety and security of all staff, guests, contractors, vendors, and the environment is a primary priority at Brookhaven National Laboratory and for the NSLS-II project management. It is the expectation that all Project staff and contractors will plan, manage, and execute their respective duties consistent with the requirements of the BNL Integrated Safety Management Systems and ensure that the facility is designed, constructed, and operated in a safe and environmentally sound manner.

Expectations for Environment, Safety, and Health (ES&H) performance have been established in the NSLS-II ES&H Plan. All work associated with this project will be conducted in a manner that ensures protection of the workers, the public, and the environment. Policies and requirements to ensure implementation of these expectations have been established and communicated to all staff, contractors, and vendors.

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.