

BESAC Report on Facility Upgrades
Approved by the Basic Energy Sciences Advisory Committee on June 9, 2016

In a December 21, 2015 letter (Appendix A), Director of the DOE Office of Science (SC), Dr. Cherry A. Murray, asked the Basic Energy Sciences Advisory Committee (BESAC) to provide an update of its assessment of the proposed upgrades to x-ray scattering facilities (both free electron laser-based sources and ring-based sources) and to the Spallation Neutron Source using the same criteria that were used in prior studies—“*the ability of a proposed upgrade or construction project to contribute to world leading science and the readiness of the upgrade or construction project to proceed to construction*”—and the same rating system.

The following criteria have been considered in the BESAC evaluation:

1. The ability of a proposed facility or upgrade to contribute to world-leading science, noting in particular the relevance to the 2015 BESAC report “Challenges at the Frontiers of Matter and Energy: Transformative Opportunities for Discovery Science.” Activities will be placed in one of three categories: (a) absolutely central; (b) important; and (c) don’t know enough yet.
2. The readiness to proceed to construction, noting whether the concept has been thoroughly studied, the R&D performed to date is sufficient, the technical challenges can be met, and the extent to which the cost to build and operate the facility is understood. Concepts will be placed in one of the three categories: (a) ready to initiate construction; (b) significant scientific/engineering challenges to resolve before initiating construction; and (c) mission and technical requirements not yet fully defined.

The five proposed facility upgrade projects are: the Advanced Photon Source Upgrade (APS-U); the Advanced Light Source Upgrade (ALS-U); the Linac Coherent Light Source II High Energy Upgrade (LCLS-II-HE); the Proton Power Upgrade (PPU) at the Spallation Neutron Source; and the Second Target Station (STS) at the Spallation Neutron Source.

Executive Summary

The Office of Basic Energy Sciences’ (BES) x-ray and neutron user facilities play an ever increasingly critical role for fundamental discovery science and innovation in the fields of Chemistry, Physics, and the Life Sciences. The impact of these facilities both within the U.S. and internationally has been tremendous. One result has been large international investments in new facilities to compete with U.S. science and technology. Not surprisingly, the fundamental technology underlying these facilities is not stagnant. New approaches are invented, developed and implemented—sometimes resulting in revolutionary improvements in the experimental capabilities, providing the opportunity to ask and answer important questions about how nature works and to drive innovations that could not be envisioned with existing facilities. The increased international competition provides both a challenge and an opportunity for the U.S. The **challenge** is to move

forward projects that will assure continued U.S. leadership in science and innovation. The **opportunity** is that in some instances new technologies exist that if implemented will guarantee U.S. leadership for decades to come.

The Office of Basic Energy Sciences is considering five major upgrade projects for the U.S. x-ray and neutron scattering facilities: the Advanced Photon Source Upgrade (APS-U), the Advanced Light Source Upgrade (ALS-U), the Linac Coherent Light Source II High Energy Upgrade (LCLS II-HE), and upgrades for the Spallation Neutron Source—the Proton Power Upgrade (PPU), and the Second Target Station (STS). The Basic Energy Science Advisory Committee (BESAC) has been asked to provide an updated assessment related to the prioritization of these projects.

X-ray storage ring light sources—responding to a major new technology

Storage ring based x-ray light sources are based on the fact that electrons that are transversely accelerated in a circular ring give off a broad spectrum of radiation (synchrotron radiation). As always, the challenge is in the details of the construction and operation of the complex facility that can accomplish this and utilize the emitted radiation. Throughout the more than 40 year history of the use of synchrotron facilities as bright sources of x-rays for experimental science there has been a continuous evolution of the associated technology. New insertion devices have been invented and implemented to provide higher brightness sources, new advanced beam lines have been designed and constructed, and new methods have been developed and implemented to hold constant the electron beam current in the ring (e.g., top-off injection). Most of these technological advances have been such that they could be implemented within the structure of an existing synchrotron during normal maintenance periods, and at relatively modest costs. New beam lines have been developed to take advantage of the advances in the x-ray source as well as advances in experimental science. Under these circumstances the APS and the ALS have remained world leading experimental facilities in the hard and soft x-ray regions of the spectrum respectively. We are now faced with the challenge of a revolutionary new design of the storage ring itself, the multi-bend achromat (MBA) lattice. The MBA lattice produces a tightly focused (round) electron beam that produces very high brightness x-rays that are delivered to the experimental beam lines. The transverse coherence of the x-ray beams is also greatly enhanced by the compact electron beams. The exceptional brightness and coherence of the x-ray beam makes possible new experiments that promise to revolutionize our ability to determine the atomic and electronic structure associated with materials, biomolecular systems, and chemical reactions. The MBA lattice design has been implemented at the MAX IV light source in Sweden and has been emulated through planned upgrades and new facilities in Europe, Asia and South America. Without the planned upgrades the APS and the ALS will soon be relegated as second tier facilities. The APS-U and ALS-U implementations of the MBA lattice are such that these facilities will leap ahead of other competing facilities worldwide and will remain in a leadership position for the foreseeable future. As such both the APS-U and the ALS-U are considered to be “**absolutely central to contribute to world leading science**” and “**ready to initiate construction**”. The APS-U project is well on its way. The ALS-U project, while at an earlier stage, is on a good trajectory.

X-ray free electron lasers—“keeping the lead”

In 2009 the Linac Coherent Light Source (LCLS) ushered in the era of x-ray free electron laser user facilities. The ultrafast pulsed nature and extreme peak brightness of the LCLS have enabled experiments that were previously not possible. As the first x-ray free electron laser facility it has been, and continues to be, world leading. New advanced hard x-ray FEL facilities are under construction in Europe and Asia. The present LCLS II project will provide the high pulse repetition rate (up to 1 MHz) and higher x-ray energy (up to 5 keV) that were recommended by the BESAC 2013 report on future U.S. x-ray facilities. The European XFEL, which will come on line in 2016/17, will provide x-ray energies above 12 keV with pulse bunches that have microsecond pulse spacing. The LCLS II High Energy Upgrade (LCLS II-HE) is an opportunity to provide truly world leading experimental capabilities for the U.S. research community by extending the x-ray energy of LCLS II to 12 keV and beyond. This corresponds to an x-ray wavelength of $\sim 1 \text{ \AA}$ —which is particularly important for high resolution structural determination experiments. The flexibility and detailed pulse structure associated with LCLS II will not be matched by other facilities under development. As such the LCLS II-HE project is considered to be **“absolutely central to contribute to world leading science”** and **“ready to initiate construction”**. The LCLS II-HE project should move ahead taking advantage of what is learned in the on-going LCLS II project.

Spallation neutron source—remaining competitive on the world stage

The SNS is presently the most powerful pulsed neutron experimental facility in the world. The SNS in combination with HFIR makes Oak Ridge National Laboratory one of the world leading experimental facilities for neutron experiments. However, the European Spallation Source, now under construction in Sweden, will soon eclipse the SNS first target station. The Proton Power Upgrade (PPU) and Second Target Station (STS) at the SNS has the potential to provide a pulsed neutron facility that remains world leading. As such the PPU and STS are considered to be **“absolutely central to contribute to world leading science”**. However several questions exist as to the detailed design and implementation of the STS and how the proton pulses from the PPU are distributed between the first and second target stations. As such the PPU and STS are considered to have **“significant scientific/engineering challenges to resolve before initiating construction”**. The committee encourages ORNL to establish a review panel to make a detailed evaluation and recommendations on the proposed designs. Such a panel should be charged with detailed analysis of the technical issues such as those related to the STS repetition rate and pulse length.

The subcommittee also recommends that SNS continue to work closely with the neutron science user community in the U.S. to develop the most exciting and robust set of “first experiments” that would fully utilize the capabilities of the STS.

The subcommittee also noted that SNS continues to struggle with the lifetime of the target of the first target station. It is acknowledged that progress has been made in this area but the development of a more robust first target is important to fully utilize the proposed PPU. It is also recognized that the full suite of planned experimental stations are not yet available for the first target station. The Oak Ridge National Laboratory should make the build-out of the experimental stations for the first target station a priority.

BESAC Process

In response to the request from the Director of the Office of Science, the directors of the facilities and the directors of the host national laboratories were asked to give presentations at the meeting of BESAC on February 11–12, 2016. The meeting was held at the Bethesda North Marriott Hotel and Conference Center. They were asked to define the proposed facility upgrade so that, what it is, and what it is meant to accomplish, are clear and how the upgrade is important to be able to contribute to world leading science. The agenda of that BESAC meeting is included in this report as Appendix B. Following the February meeting, BESAC established the BESAC Facility Upgrade Subcommittee, Chaired by the Chair of BESAC, Dr. John C. Hemminger. The full membership of the subcommittee is provided in Appendix C to this report. The subcommittee held one meeting over a three-day period in April, 2016. The draft report from the subcommittee was presented to the full BESAC committee on June 9, 2016.

The agenda of the April subcommittee meeting is included as Appendix D. On April 14, 2016 the subcommittee heard presentations by Dr. Michael Witherell, Director of LBNL, and the team from the ALS. On April 15, the subcommittee heard presentations by Dr. Peter Littlewood, Director of ANL, and the team from the APS in the morning, and by the team from the SNS in the afternoon (Dr. Thom Mason, Director of ORNL, was in attendance at the meeting and contributed to the discussions). On April 16, the subcommittee heard presentations by Dr. Chi-Chang Kao, and the team from the LCLS. During the afternoon of April 16, the subcommittee reviewed the material that had been presented by each of the teams and discussed each of the upgrade proposals in detail. Each of the facilities were asked to address questions that were provided in a March 20, 2016 request for information from the BESAC subcommittee. This request for information document is included here as Appendix E.

Science and Technology Leadership and the International Context

X-ray and neutron experiments are powerful experimental probes of the fundamentals as well as the technological applications of chemistry, physics, and the life sciences. The U.S. has been the world leader in the development of accelerator based x-ray light source user facilities for over 40 years and the Spallation Neutron Source is at present the most powerful pulsed neutron source user facility available for research in the world. Neutron and x-ray experiments are complementary and the development of fundamental understanding of the properties of modern materials requires both kinds of experiments.

Historical Status of X-ray User Facilities

The ALS and the APS are electron storage rings that provide synchrotron radiation, with the ALS optimized for soft x-ray science (photon energy below 2 keV) and the APS optimized for hard x-ray science (photon energy above 2 keV). Soft x-ray experiments are optimal for probing the electronic structure of chemicals and materials, whereas hard x-ray experiments are optimal for determining the atomic structure of materials and penetrating into condensed phase media. In contrast, the LCLS is the first hard x-ray free electron laser (FEL) user facility in the world, providing ultra-short, highly coherent pulsed x-rays, optimal for probing the structure and time dependence of

processes. As was pointed out in the July, 2013 BESAC report on the Future of X-ray Light Sources, “*The success of the U.S. light source enterprise has inspired both Europe and Asia to emulate the U.S. resulting in tremendous light source developments in both regions.*” In particular, the aggressive pursuit of multi-bend achromat (MBA) lattices for synchrotron facilities has been successfully implemented at the MAX IV facility in Sweden. Their success is being emulated through planned upgrades and new facilities both in Europe and Asia. The 2013 BESAC report pointed out that, due to the rapidly changing synchrotron technology landscape, the plans that existed at that time for U.S. x-ray sources would not keep the U.S. facilities internationally competitive. The BESAC report challenged BES and the host national labs to develop upgrade plans for the U.S. user facilities that would result in continued U.S. leadership for the foreseeable future. The present APS-U, ALS-U, and LCLS-II-HE projects aim to address this challenge. The Office of Basic Energy Sciences should ensure that U.S. storage ring x-ray sources reclaim their world leadership position.

In the FEL arena, hard x-ray FELs that will be competitive with or surpass the capabilities of LCLS will be on-line in Germany, Korea, and Switzerland in the near future. It is essential that the facilities the U.S. science community relies on remain internationally competitive in the face of the innovative developments of storage rings and free electron lasers in other countries.

Historical Status of Neutron User Facilities

The U.S. has both reactor based and spallation source based sources of neutrons as components of its neutron user facilities. The reactor sources provide a high flux continuous source of slow neutrons, whereas the SNS is a high intensity short pulsed source. Both types of sources are crucial components of the experimental user facilities for the U.S. materials science community. The strong interaction between neutrons and hydrogens in materials makes neutron experiments particularly important to the soft matter, biological, and polymer sciences communities. Additionally, the fact that neutrons are spin $\frac{1}{2}$ particles makes neutron experiments particularly effective probes of the magnetic properties of materials. At the present time the SNS is the most powerful pulsed neutron user facility in the world. However, as with the x-ray source facilities, the technology of neutron sources is developing rapidly. The European Spallation Source (ESS), under development in Lund, Sweden with first neutrons planned to be available in 2019 (with full operations by 2024), will provide approximately an order of magnitude higher neutron flux than the SNS. Such enhanced performance will enable new opportunities for European researchers in the fields of materials science. It is critical that an upgrade path be followed that will provide for continued U.S. excellence in neutron science. An upgrade to the SNS will enable exciting new science. For example, it will enable studies of magnetic dynamics in solids while the atomic spacing is tuned with high pressure. In addition, by combining the enhanced brightness with dynamic nuclear polarization, there will be a gain of more than a thousand for diffraction studies determining the positions of hydrogen atoms and water molecules in biological systems from photosynthetic machinery to enzymes.

Assessment of the Upgrade Projects

The future of hard x-ray science: APS-U

Following the 2013 BESAC report on the “*Future of X-ray Light Sources*”, the APS and Argonne National Laboratory leadership in collaboration with the x-ray science community revised the plans for the APS-U to take advantage of the new multi-bend achromat lattice approach to the synchrotron storage ring. They have aggressively moved forward and are well along on the project. Plans are in place to guarantee that the beam lines will be compatible with the upgraded synchrotron at the time of commissioning of the upgraded ring. A component of the proposed upgrade is to implement “on-axis, swap out injection” of electrons into the storage ring. This unique approach to keeping the ring current constant doesn’t just incrementally replace the charge in a given electron bunch that is lost over time, it replaces the entire electron bunch with a new one containing the proper charge. This is done on a bunch-by-bunch basis as the charge in the bunches is depleted thru Coulomb scattering. This approach has not been implemented at synchrotron facilities previously, but it is likely that the international community will follow the U.S. in implementing this technique. It should be recognized that the international competition is extremely keen in the area of hard x-ray science. As such the APS-U upgrade is critical. The subcommittee considers the APS-U project as “**absolutely central**” and “**ready to initiate construction**”.

In the development of the APS-U care has been taken to pay attention to the development of the APS managed beam lines so that they can take advantage of the unique new properties of the APS-U x-ray beam (coherence, small spot size, and extreme brightness). The project is budgeted in such a way to “deliver the high quality beam to the samples.”

The computational and theoretical science program at the APS is developing. However, it is important that this component of the science move forward quickly in sequence with the experimental upgrade. As with all the facilities, the ability of users to process and analyze their data while performing experiments is crucial to accelerating the science that is accomplished as well as optimizing the use of precious beam time.

The future of soft x-ray science: ALS-U

For an extended period of time the ALS has been a world-class premier soft x-ray user facility. The successful development of multi-bend achromat lattices as demonstrated at MAX IV provide an opportunity to upgrade the ALS such that it will remain the world leading facility in this area of science for the foreseeable future. The upgraded lattice will result in a truly coherent x-ray source in the soft x-ray energy region. Like the APS-U, the ALS-U will implement a variation of the on-axis, swap out injection scheme. In contrast to the bunch-by-bunch scheme used by APS-U, the ALS-U scheme will periodically replace an entire bunch train in the ring with a fresh bunch train from an accumulator ring in the ALS tunnel. The swapped out bunch train is then transferred to this accumulator ring where new charge is added and can then be re-injected into the ALS-U ring. The coherence of the beam will make possible powerful new experiments. The installation of the new lattice will require a “dark period” during which time the x-ray source will not be available to the science community. Importantly, plans are under development at the ALS to upgrade the present beam lines in advance so that they will be

compatible with the upgraded storage ring immediately after it has been commissioned—thus limiting the “dark period”.

The ALS has held one workshop on the ALS-U possibilities. However, the engagement with the user community on the detailed plans for the beamline upgrades that would be associated with the ALS-U has not been as robust as it needs to be. This is particularly important as the ALS develops the plans mentioned above to upgrade the present beam lines in advance of the ring upgrade. The ALS management is encouraged to enhance their outreach efforts to engage the user community in the design and planning for the ALS-U project and the associated beam line upgrades.

The subcommittee considers the ALS-U project as **“absolutely central”** and **“ready to initiate construction”**.

There is a historically strong coupling between the experiments at the ALS and the computational and theoretical science community. The CAMERA project (the Center for Advanced Mathematics for Energy Research Applications) is highly effective at LBNL and is reaching out to other national user facilities.

The future of X-ray Free Electron Lasers: LCLS II-HE

The LCLS has been a stunningly successful science story. In addition, LCLS II will convert LCLS into a true high pulse rate (~1MHz) x-ray laser source. This advance will allow for qualitatively new types of x-ray science experiments that one could only fantasize about previously. The LCLS II will be the premier x-ray FEL at energies up to ~5 keV. However, other x-ray FELs will come on line in the near future providing severe challenges to the dominant position of the LCLS. The LCLS II-HE will increase the photon energy to above 12 keV, providing access to experiments that involve additional elements (e.g. Se which is often used in studies of biological systems). Also, at 12 keV the photon wavelength approaches 1Å allowing higher resolution diffraction experiments. These characteristics allow exciting new experiments on a variety of systems including biological samples. In addition, at the higher photon energies enhanced x-ray penetration allows for new experiments on buried systems and extreme high density systems. Since the LCLS-II enhancement of LCLS is not yet operational, it is expected that much will be learned as LCLS-II evolves that can be used to optimize the LCLS II-HE upgrade. The basics of the upgrade plan is well developed and the subcommittee considers the LCLS II-HE to be **“absolutely central”** and **“ready to initiate construction”**.

The future for neutron science: PPU and STS

In light of the development of the ESS, it is clear that retaining U.S. international competitiveness in neutron science will require an upgrade of the SNS to have a second target station and associated experimental stations. A straightforward upgrade or less costly modification of the SNS first target station (FTS) to address the future competition would be neither effective nor feasible. Implementation of any second target at the SNS will require a proton power upgrade. The technical plans for the PPU are well developed although some technical aspects will depend on the details of the final plan for the STS.

With the PPU available, multiple options exist for the details of the STS project (e.g., in terms of the optimal way that the proton pulses are shared between the first and second target stations, the desired pulse length and power, details of the proposed rotating tungsten target, etc.). The subcommittee was not convinced that the detailed design

presented for the STS was optimum given the future international competition. Among other issues, plans should be considered that take advantage of the ability to increase the repetition rate and the ways to increase the average brightness of the STS. A detailed study of the feasibility of running the STS at 20 Hz rather than 10 Hz is warranted.

The combined PPU and STS are considered to be “**absolutely central**” to contribute to world-leading neutron science. However, many questions remain regarding the detailed design and implementation of the STS. The details of the PPU and the STS are intimately coupled. Given the questions that remain, BESAC considers that there exist “**significant scientific/engineering challenges to resolve before initiating construction**”. Furthermore, BESAC strongly encourages ORNL to establish a review panel to make a detailed evaluation and recommendations on the proposed designs. Such a panel should be charged with detailed analysis of the technical issues such as those related to the STS repetition rate and pulse length.

The subcommittee also recommends that SNS continue to work closely with the neutron science user community in the U.S. to develop the most exciting and robust set of “first experiments” that would fully utilize the capabilities of the STS.

The subcommittee was also provided with a limited amount of information on the proposed budget for the project. Based on the information provided, the projected cost of the conventional construction appeared to be excessive.

The subcommittee also noted that SNS continues to struggle with the lifetime of the target of the first target station. It is acknowledged that progress has been made in this area but the development of a more robust first target would be important to fully utilize the proposed PPU. It is also recognized that the full suite of planned experimental stations are not yet available for the first target station. The Oak Ridge National Laboratory should make the build-out of the experimental stations for the first target station a priority.

The facilities were also asked to provide information on their plans to “*insure that computational science and theory are seamlessly integrated into the facility*”. This is particularly important to optimize the usefulness of experimental data from the present SNS and the future upgraded facility. Historically, this has been a significant problem for the SNS. However, the SNS does appear to be making some progress in this area with the development of the “Compute and Data Ecosystem for Science” (CADES) program. The lab is strongly encouraged to continue the development and implementation of this project for both the first target station experiments and future experiments on the STS.

Summary Table of Assessment

Facility Upgrade	Criteria 1	Criteria 2
APS-U	Absolutely Central	Ready to initiate construction
ALS-U	Absolutely Central	Ready to initiate construction
LCLS II-HE	Absolutely Central	Ready to initiate construction
Proton Power Upgrade	Absolutely Central	Significant scientific/engineering challenges to resolve before initiating construction
SNS Second Target Station	Absolutely Central	Significant scientific/engineering challenges to resolve before initiating construction

Staging

It is projected that the APS-U and the ALS-U projects will each entail facility dark periods of on the order of one year. It is essential that the staging of the upgrades of the storage ring x-ray sources be managed in such a manner as to minimize the impact of the dark periods on the user community.

Appendix A

Charge letter from Dr. Cherry A. Murray, Director of the Office of Science



Department of Energy
Office of Science
Washington, DC 20585

Office of the Director

December 21, 2015

Professor John C. Hemminger
Chair, Basic Energy Sciences Advisory Committee
Professor of Chemistry
Aldrich Hall 160
University of California, Irvine
Irvine, California 92697

Dear Professor Hemminger:

Thank you very much for your continuing service to the Office of Science and the scientific communities that it serves as the Chair of the Basic Energy Sciences Advisory Committee (BESAC). In particular, thank you for your recent outstanding work on the BESAC report, *Challenges at the Frontiers of Matter and Energy: Transformative Opportunities for Discovery Science*. This report provides crucial advice to BES on the breakthrough potential of current and prospective energy science frontiers toward transformative impacts for science and society. As the new report notes, enabling success in seizing the transformative opportunities and in meeting the grand challenges will require targeted investments from BES in areas that include instrumentation and tools, and specifically in the world-leading large-scale user facilities that BES supports. I need your help now in this connection.

I am writing to present a new charge to BESAC, related to the prioritization of upgrades of existing user facilities and major construction projects for new user facilities. This charge is directed by the 2016 Omnibus appropriation for BES that stated:

Since the February 2013 and the July 2013 Basic Energy Sciences Advisory Committee (BESAC) studies of BES facilities, the mix and status of ongoing and prospective BES major facility upgrades and construction projects have changed. Therefore the BESAC is directed to update its assessment of the proposed upgrades to x-ray scattering facilities (both free-electron laser-based sources and ring-based sources) and to the Spallation Neutron Source using the same criteria that were used in prior studies-the ability of a proposed upgrade or construction project to contribute to world leading science and the readiness of the upgrade or construction project to proceed to construction-and the same rating system. The assessment shall include a prioritization of the next three to five projects and be submitted to the Committees on Appropriations of both Houses of Congress not later than 180 days after the enactment of this Act.



The following are the two criteria to be considered in your evaluation:

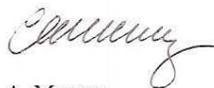
1. The ability of a proposed facility or upgrade to contribute to world-leading science, noting in particular the relevance to the 2015 BESAC report “Challenges at the Frontiers of Matter and Energy: Transformative Opportunities for Discovery Science.” Activities will be placed in one of three categories: (a) absolutely central; (b) important; and (c) don’t know enough yet.
2. The readiness to proceed to construction, noting whether the concept has been thoroughly studied, the R&D performed to date is sufficient, the technical challenges can be met, and the extent to which the cost to build and operate the facility is understood. Concepts will be placed in one of three categories: (a) ready to initiate construction; (b) significant scientific/engineering challenges to resolve before initiating construction; and (c) mission and technical requirements not yet fully defined.

Three categories of facilities are to be considered in the prioritization:

- **Free electron laser based x-ray light sources**
 1. SLAC LCLS-II High Energy Upgrade (LCLS-II-HE) (i.e., additional cryomodules in existing tunnel)
- **Ring-based x-ray light sources**
 1. ANL Advanced Photon Source Upgrade (APS-U)
 2. LBNL Advanced Light Source Upgrade (ALS-U)
- **Spallation based neutron scattering sources**
 1. ORNL Spallation Neutron Source Proton Power Upgrade (SNS PPU)
 2. ORNL Spallation Neutron Source Second Target Station (SNS STS)

I would appreciate receiving a written report by June 30, 2016.

Sincerely,



C. A. Murray
Director, Office of Science

Appendix B
Basic Energy Sciences Advisory Committee, February 11-12, 2016
Agenda
Bethesda North Marriott Hotel and Conference Center

Thursday, February 11, 2016		
8:00am – 8:20am	Executive Session for COI and other issues	BESAC members only
8:20am – 8:30am	Welcome and Introduction	John C. Hemminger, BESAC Chair University of California, Irvine
8:30am – 9:00am	News from the DOE Office of Science	Cherry Murray, Director Office of Science
9:00am – 9:45am	News from Office of Basic Energy Science	Harriet Kung, Director Office of Basic Energy Sciences
9:45am – 10:15am	Break	
10:15am – 10:45am	Challenges at the Frontiers of Matter and Energy: Transformative Opportunities for Discovery Science	John Sarrao Los Alamos National Lab
10:45am – 11:30am	Office of Advanced Scientific Computing Research	Steve Binkley, Director Office of Advanced Scientific Computing Research
11:30pm – 1:00pm	Lunch on your own	
1:00pm—1:45pm	Office of Biological and Environmental Research	Sharlene Weatherwax, Director Office of Biological & Environmental Research
1:45pm – 2:30pm	Basic Research Needs for Environmental Management Workshop	Sue Clark Pacific Northwest National Lab
2:30pm – 3:00pm	LCLS-II-High Energy Upgrade	Chi-Chang Kao, Director SLAC National Accelerator Lab
3:00pm – 3:10pm	Advanced Light Source Upgrade Introduction	Mike Witherell, Director Lawrence Berkeley National Laboratory
3:10pm—3:30pm	Advanced Light Source Upgrade	Roger Falcone, Director of Advanced Light Source, Lawrence Berkeley National Laboratory
3:30pm – 4:00pm	Break	
4:00pm – 4:30pm	Advanced Photon Source Upgrade	Peter Littlewood, Director Argonne National Laboratory
4:30pm – 5:00pm	News from the Under Secretary for Science and Energy	Lynn Orr, Under Secretary for Science and Energy
5:00pm -- 5:30pm	Public Comment Session	
Friday, February 12, 2016		
8:00am – 8:30am	Preparation for Facilities Division COV	James Murphy, BES Division Director of Scientific User Facilities
8:30am – 9:00am	SNS Proton Power Upgrade (SNS PPU)	Thom Mason, Director Oak Ridge National Laboratory
9:00am – 9:30am	SNS Second Target Station (SNS STS)	Paul Langan, Associate Lab Director for Neutron Sciences Oak Ridge National Laboratory
10:00am—11:30am	Discussion of Plans and Process for Addressing the BESAC Charge	BESAC

Appendix C

Membership of the BESAC Subcommittee on Facility Upgrades.

Name	Institution
BESAC Members	
Sylvia Ceyer	Massachusetts Institute of Technology
John Hemminger	University of California - Irvine
Tony Rollett	Carnegie Mellon University
Gary Rubloff	University of Maryland
John Tranquada	Brookhaven National Lab
USA Attendees	
Russell Hemley	Carnegie Institution of Washington
Wayne Hendrickson	Columbia University
Despina Louca	University of Virginia
Robert Briber	University of Maryland
Foreign Attendees	
Tetsuya Ishikawa	RIKEN
Zhentang Zhao	SINAP, CAS
Mikael Eriksson	MAX-IV
Andreas Schreyer	European Spallation Source
Henry Chapman	CFEL, DESY
Wolfgang Eberhardt	DESY
Ferenc Mezei	European Spallation Source

Appendix D

BESAC Subcommittee on BES Facility Upgrade Prioritization Meeting Agenda **April 14 - 16, 2016** Washington Dulles Marriott Suites (Ballroom) 13101 Worldgate Drive, Herndon, VA 20170

Thursday, April 14, 2016		
11:30am – 1:00pm	Working Lunch*	DOE and BESAC Subcommittee members only
1:00pm – 1:20pm	Executive Session	DOE and BESAC Subcommittee members only
1:20am – 1:30pm	Break	
1:30pm – 3:00pm	Advanced Light Source Upgrade	Mike Witherell and LBNL Team
3:00pm – 3:20pm	Intermission	
3:20pm – 4:20pm	Q&A	BESAC Subcommittee & LBNL
4:20pm – 5:20pm	Subcommittee Discussion of ALS-U	BESAC Subcommittee
5:30 – 6:30pm	Working Dinner*	DOE and BESAC Subcommittee members only
7:00pm – 9:00pm	Subcommittee Discussion (Optional)	BESAC Subcommittee
Friday AM, April 15, 2016		
8:00am – 8:20am	Executive Session	DOE and BESAC Subcommittee members only
8:20am – 8:30am	Break	
8:30am – 10:00am	Advanced Photon Source Upgrade (APS-U)	Peter Littlewood and ANL Team
10:00am – 10:20am	Intermission	
10:20am – 11:20am	Q&A	BESAC Subcommittee & ANL
11:20am – 12:20pm	Subcommittee Discussion of APS-U	BESAC Subcommittee
12:30pm – 1:30pm	Working Lunch*	DOE and BESAC Subcommittee members only
Friday PM, April 15, 2016		
1:30pm – 2:30pm	ORNL SNS Proton Power Upgrade (SNS PPU) and SNS Second Target Station (SNS STS)	Thom Mason and ORNL Team
2:30pm – 2:50pm	Intermission	
2:50pm – 3:50pm	ORNL SNS Proton Power Upgrade (SNS PPU) and SNS Second Target Station (SNS STS) (continued)	Thom Mason and ORNL Team
3:50pm – 5:00pm	Q&A	BESAC Subcommittee & ORNL
5:00pm – 6:00pm	Subcommittee Discussion of SNS-PPU and SNS-STS	BESAC Subcommittee
6:00pm – 7:00pm	Working Dinner*	DOE and BESAC Subcommittee members only
7:00pm – 9:00pm	Subcommittee Discussion (Optional)	BESAC Subcommittee

Saturday AM, April 16, 2016		
8:00am – 8:20am	Executive Session	DOE and BESAC Subcommittee members only
8:20am – 8:30am	Break	
8:30am – 10:00am	LCLS-II-High Energy Upgrade (LCLS-II-HE)	Chi-Chang Kao and SLAC Team
10:00am – 10:20am	Intermission	
10:20am – 11:20am	Q&A	BESAC Subcommittee & SLAC
11:20am – 12:20pm	Subcommittee Discussion of LCLS-II-HE	BESAC Subcommittee
12:30pm – 1:30pm	Working Lunch*	DOE and BESAC Subcommittee members only
Saturday PM, April 16, 2016		
1:30pm – 5:00pm	Subcommittee Discussion	BESAC Subcommittee
5:00pm	Adjourn	

*Worldgate Conference Room

Appendix E

BESAC Prioritization Subcommittee Information Request (Updated 3/20/16, see additions in red)

- **Existing Facility Impact**
 - What are the major accomplishments of your existing facility (science, source, users, pubs) in the last 10 years?
 - What challenges have limited your facility from reaching its full potential and how are they being mitigated?

- **Impact of the Facility Upgrade**
 - Why is the upgrade needed now? What opportunities are missed by delaying the upgrade?
 - What are the revolutionary, versus evolutionary, new technical capabilities of the upgraded source?
 - What are the revolutionary, versus evolutionary, new science experiments (Killer Apps)?
 - What are the first ten ground-breaking experiments?
 - **What programs are in place and new programs planned to insure that computational science and theory are seamlessly integrated into the facility?**
 - How will your upgraded facility expand its utility into disciplines or fields of science not currently using your facility?
 - **How will your upgraded facility serve the science needs of your present major user communities?**

- **Domestic & International Competition**
 - What is the domestic competition for your upgraded facility?
 - How does your upgrade complement existing/planned US facilities?
 - What is the international competition; how is your upgraded facility world leading and for how long?

- **Technical Challenges & Risks**
 - What R&D is required to enable the full source & science capabilities of your new facility?
 - What are the technical challenges & risks involved in upgrading your facility?
 - What is the realistic down time (dark period) that your planned upgrade will require?

- **Cost & Schedule**
 - What is the cost of the upgrade (source, beamlines, management **and contingency**) and the basis of your estimate?
 - What is your estimate of the optimized schedule and budget profile?
 - What is the current and future estimate of the facility operating cost; starting when?
 - **What are the outstanding costs to fully build out all the beamlines/flight paths beyond the costs identified for your upgrade?**
- **Capacity**
 - How many experimental endstations are there now and what upgrades are required for each to make use of the new source?
 - How many entirely new experimental endstations will be created?
 - How many experimental endstations will be ready on day one; what fraction of the total is that?
 - What are the current & projected future user numbers?
- **Photons: FELs versus Rings**
 - Can a high average power FEL with higher average & peak brightness exceed the capabilities of your ring upgrade?
 - How does your FEL compete with the multiplexing capabilities of a ring to address capacity issues?
- **Neutrons: STS versus Alternatives**
 - **What are the possibilities for capturing the new cold neutron science capabilities and STS peak brightness performance by considering novel moderator options at SNS first target station; what capacity enhancements are possible by building out all remaining flight paths at SNS and HFIR?**
- **Stakeholder Engagement**
 - What external reviews, workshops, etc. have you held to ascertain the demand and potential scientific breakthroughs that your upgraded facility will produce? **Provide the subcommittee with links to pdf of reports from each review/workshop as a supplement to the written documentation you provide by April 4.**