Fiscal Year 2008 Self-Evaluation

Contractor Performance Evaluation and Measurement Plan

SLAC National Accelerator Laboratory

Volume 1, Science and Technology, Goals 1 – 3

Submitted to the U.S. Department of Energy
October 31, 2008

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Introduction

Leland Stanford Junior University (Stanford University [SU]) is under contract with the Department of Energy (DOE) to manage the SLAC National Accelerator Laboratory (SLAC). Clause H.015(a) of Contract Number DE-AC02-76-SF00515 states that "performance-based management shall be the key enabling mechanism for establishing the DOE Contractor expectations on oversight and accountability." Moreover, the specific mechanism for evaluating the performance-based approach (mission accomplishment, stewardship and operational excellence) from October 1, 2007 to September 30, 2008 (fiscal year [FY]) is the FY08 Contractor Performance Evaluation and Measurement Plan (PEMP), which is organized by performance goals (goals), performance objectives (objectives), performance measures (measures) and performance targets (targets). The performance-based approach focuses on SLAC's performance against these goals. The DOE Office of Science (SC) mandates that each SC laboratory establish the same eight goals in the PEMP. The eight goals are:

1. Provide for Efficient and Effective Mission Accomplishment
2. Provide for Efficient and Effective Design, Fabrication, Construction and Operations of Research Facilities
3. Provide Effective and Efficient Science and Technology Program Management
4. Provide Sound and Complete Leadership and Stewardship of the Laboratory
5. Sustain Excellence and Enhance Effectiveness of Integrated Safety, Health and Environmental Protection
6. Deliver Efficient, Effective and Responsive Business Systems and Resources that Enable the Successful Achievement of the Laboratory Mission(s)
7. Sustain Excellence in Operating, Maintaining and Renewing the Facility and Infrastructure Portfolio to Meet Laboratory Needs
8. Sustain and Enhance the Effectiveness of Integrated Safeguard and Security Management (ISSM) and Emergency Management Systems

SC also requires each SC laboratory to use the same objectives to measure progress against the goals.

This document reports SLAC's success in achieving the three science and technology (S&T) goals (1 through 3) and objectives. The report also incorporates performance outside of the specific goals and objectives, including identifying key achievements and opportunities for improvement.

Executive Summary

Overall, SLAC met expectations in the operation and construction of facilities and in the quality of the leadership provided, earning a 'B+' in these areas. In the accomplishment of science mission, SLAC exceeded expectations in the impact of results on the field earning an 'A-'.

Major accomplishments were in:

1. Commissioning of the LCLS electron beam
2. Transition of accelerator operations into LCLS
3. While management changes were needed, both the LCLS and LUSI projects met schedule and budget milestones in addition to achievement of technical goals
4. High efficiency SSRL operations and science delivery
5. Effective changes in the accelerator research effort in response to cuts in the ILC program
6. The response of the *B* Factory program to the FY08 funding difficulties, rapidly and effectively optimizing the program in the face of the early termination
7. The launch and highly successful early operations of the GLAST/Fermi satellite mission
8. All the programs at the laboratory produced excellent science

The laboratory successfully dealt with challenges in the LCLS construction project. While the quality of interactions between laboratory management and the program office improved markedly, continued effort will be needed to ensure full transparency and fully effective communications in the future.

Overall, FY08 presented one of the most challenging years in the laboratory's history. It is the leadership's assessment that the challenges were effectively met and the overall mission transition continued to move forward.

For each of the three S&T goals, performance was in the range from 'A-' to 'B+' using the DOE letter grade/numeric score scales established in the PEMP. The laboratory's overall score is 3.3 (B+).

Science and Technology Score Calculation

Element		Letter Grade	Numerical Score	Goal Weight	Weighted Score	Total Score
1	Provide of Efficient and Effective Mission Accomplishments	A-	3.5	28%	1.0	
2	Provide for Efficient and Effective Design, Fabrication, Construction and Operations of Research Facilities	B+	3.1	52%	1.6	
3	Provide Effective and Efficient Science and Technology Program Management	B+	3.3	20%	0.7	
					Total Science and Technology Score	**3.3**

Goal 1 Provide Efficient and Effective Mission Accomplishment

The contractor produces high-quality, original and creative results that advance science and technology; demonstrates sustained scientific progress and impact; receives appropriate external recognition of accomplishments; and contributes to overall research and development goals of the department and its customers.

The weight of this goal is 28%.

This goal measures the overall effectiveness and performance of the contractor in delivering science and technology results which contribute to and enhance the DOE's mission of protecting our national and economic security by providing world-class scientific research capacity and advancing scientific knowledge by supporting world-class, peer-reviewed scientific results, which are recognized by others.

BES/BER (63%)

Element		Letter Grade	Numerical Score	Objective Weight	Weighted Score	Total Score
1	Provide of Efficient and Effective Mission Accomplishments					
1.1	Science and Technology Results Provide Meaningful Impact on the Field	A-	3.5	50%	1.7	
1.2	Provide Quality Leadership in Science and Technology	B+	3.4	20%	0.7	
1.3	Provide and Sustain Science and Technology Outputs that Advance Program Objectives and Goals	B+	3.3	15%	0.5	
1.4	Provide for Effective Delivery of Science and Technology	A-	3.7	15%	0.6	
					BES and BER Science and Technology Score	3.5
					BES and BER Funding Weight (63%)	**2.2**

HEP (37%)

Element		Letter Grade	Numerical Score	Objective Weight	Weighted Score	Total Score
1	Provide of Efficient and Effective Mission Accomplishments					
1.1	Science and Technology Results Provide Meaningful Impact on the Field	A-	3.6	30%	1.1	
1.2	Provide Quality Leadership in Science and Technology	B+	3.3	30%	1.0	
1.3	Provide and Sustain Science and Technology Outputs that Advance Program Objectives and Goals	A-	3.5	30%	1.0	
1.4	Provide for Effective Delivery of Science and Technology	B+	3.4	10%	0.3	
					HEP Science and Technology Score	3.4
					HEP Funding Weight (37%)	**1.3**

Total Goal 1 Score: 3.5 (A-)

BES/BER

A ➤ Stanford Synchrotron Radiation Lightsource (SSRL)

SSRL is a national user facility that provides synchrotron radiation to a broad user community to investigate objects at the atomic and molecular level, allowing a wide variety of research in basic and applied studies on the structure of matter. About 2,000 researchers use SSRL each year from industry, government laboratories and universities and represent the fields of astronomy, biology, chemical engineering, chemistry, electrical engineering, molecular environmental science, geology, materials science, medicine and physics. SSRL underwent its triennial DOE Basic Energy Science (BES) review in FY08 and received excellent results. The transmittal letter by Pedro Montano[1] states that SSRL has shown a high level of scientific productivity with world-class science being performed and that SPEAR3 has performed superbly with high reliability and infrequent faults.

In FY08, the SSRL facility provided 28 end-stations on 23 beam lines (BL), as well as ancillary equipment and supporting infrastructure. The construction of three additional beam lines was completed and commissioning initiated in FY08, thus completing the SPEAR3 beam line upgrade. For the FY09 run, 30 end stations on 25 beam lines will become available. Two additional beam lines are under construction. SSRL also has ongoing training opportunities to disseminate information, technological and theoretical developments and to encourage reciprocal exchange of information and thought, from both pure science and practical perspectives. The audience is broad and topics typically include methodological and instrumentation developments, highlights of new capabilities developed at SSRL, accelerator upgrades, theoretical applications, etc. Much of this information is also provided on-line via the SSRL web[2]. In FY08, SSRL also managed the Gateway program, which was an educational program tailored specifically for Mexican-American and Mexican communities in undergraduate and graduate education by engaging student scholars in science and engineering research programs at all levels.

SSRL provides beam lines, instrumentation and supporting facilities to enable its user research programs in the following areas.

Studies of Condensed Matter – (a) structures of materials including amorphous solids and liquids, polymer systems, catalysts, doped semiconductors, magnetic storage materials, nanomaterials and environmentally relevant systems; (b) structures of and phase transitions in surfaces, interfaces and thin surface layers; (c) the determination of electronic states in metals, semiconductors, magnetic systems, superconductors, ultra-thin layers, interfaces and small clusters; (d) kinetics of structural changes in materials; (e) fundamental x-ray scattering and absorption physics; and (f) chemical reactivities in the gas phase.

Structural Molecular Biology – (a) protein structure and function through macromolecular crystallography studies; (b) protein metal active site structure and function through x-ray absorption spectroscopy (edge and extended fine structure) studies; (c) solution protein structure studies, static and time-resolved protein folding studies and fiber diffraction by small angle x-ray scattering. Specialized facilities for handling biological materials are available. A high brightness wiggler beam line for structural molecular biology provides three experimental stations (funded by the Office of Biological and Environmental Research [BER]).

Molecular Environmental Science – (a) noninvasive *in-situ* analysis of dilute, hydrated and chemically/structurally complex natural samples; (b) study of microstructures, chemical microgradients and microenvironments such as occur in biofilms, pore spaces and around plant roots, that control the transformation of contaminants in the environment.

1 http://www-group.slac.stanford.edu/oa/selfevaluation/2008/SSRL_2008DOE-Review-letter.pdf

2 http://www-ssrl.slac.stanford.edu

Facility Research and Development – Development of new experimental capabilities at SSRL is usually undertaken by SSRL faculty and staff scientists, often in collaboration with users once the users' needs have been assessed through workshops or other meetings. By actively driving research on the beam lines, the SSRL faculty and scientific staff are able to develop and maintain state-of-the-art experimental capabilities at SSRL as well as create new user communities. These programs are quite varied and many of the new programs will take advantage of the higher brightness capabilities of SPEAR3 through the implementation of advanced spectroscopic capabilities, coherence and microfocusing.

Objective 1.1 Science and Technology Results Provide Meaningful Impact on the Field

SSRL carries out a broad user-based research program in the physical, chemical and biological sciences as well as in targeted research areas through its facilities research and development (R&D) activities. The user research is best seen through the extensive publications list presented in the Publications Appendix[3] and through the SSRL Highlights, which are available on the SSRL website[4]. Selected accomplishments from the SSRL facilities R&D activities are described below.

Top-off tracking studies for SPEAR3

We are close to completing comprehensive accelerator top-off injection computer simulations. Through these simulations, we have determined a set of magnet strength interlocks that will guarantee the safety of top-off injection. The computer algorithms developed at SSRL are already being used as a model for top-off tracking studies at National Synchrotron Light Source II (NSLS-II) and in Taiwan.

Inelastic Scattering and Advanced Spectroscopy Facility for SPEAR3

After last year's upgrade with both additional analyzers and increased monochromator resolution, the high resolution spectrometer on BL6-2 has moved into routine operation in which the number of proposals and assigned beam times for x-ray emission spectroscopy (XES)/resonant inelastic x-ray scattering (RIXS) and x-ray Raman spectroscopy (XRS) work has steadily increased. Very promising studies have been carried out in a number of areas including the oxygen evolving complex in photosystem II and the metal clusters in the nitrogen-fixation enzyme nitrogenase which will enhance the understanding of the structure-function relationship of this important biocatalyst.

Rapid Scan X-ray Spectroscopy Imaging

Originally initiated for the Archimedes Palimpsest x-ray imaging project, a rapid-scan X-ray fluorescence/spectroscopy imaging setup for work at 10-100 µm resolution was developed. This setup is specialized for the imaging of large objects and is complementary to other burgeoning x-ray fluorescence (XRF) imaging projects at SSRL. In particular, work on medical brain imaging has been carried out with this setup and a new x-ray absorption spectroscopy (XAS) imaging program on dinosaurs and other fossils has been started.

Molecular Environmental and Interface Science

Molecular Environmental and Interface Science (MEIS) research focuses on the fundamental interfacial, molecular- and nano-scale processes that control the behavior of contaminants and nutrients in the environment. This research makes significant use of the entire suite of SSRL-based synchrotron techniques to provide direct in-situ probes of physical and electronic structure. Basic research in these areas at SSRL contributes directly to important U.S. national priorities in the areas of energy, environment and homeland security.

Education and outreach is an important aspect of this program. In FY08, this program supported: (a) a three-day SSRL School on Hard X-ray Absorption Techniques in Materials and Environmental Sciences (May 15-17), (b) a workshop on New Opportunities in Microfocusing at the SSRL/LCLS

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3 http://www-group.slac.stanford.edu/oa/selfevaluation/2008/fy08pubsappendix.pdf

4 http://www-ssrl.slac.stanford.edu/science/sciencehighlights.html

2007 Annual Users Meeting and (c) an international symposium on Molecular Scale Chemical and Biogeochemical Processes Affecting the Mobility of Metal and Radionuclide Contaminants in the Subsurface, hosted at the 2008 Goldchmidt Geochemistry conference, July 13-18, 2008 in Vancouver, Canada and (d) the sixth Stanford-Berkeley Summer School on Synchrotron Radiation and its Applications in Physical Science. Several new user groups joined the SSRL MEIS community in FY08.

A new DOE-BER National Lab Science Focus Area (SFA) research center was funded to study the structure/property relationships and environmental geochemical dynamics of complex nano-materials, with emphasis on biogenic uraninite and iron oxides. This center and its research projects will leverage SSRL capabilities to elucidate the fundamental processes and materials that underpin environmental remediation science and will facilitate the closure of contaminated DOE sites. Results from this program have already led DOE at the Hanford site to escalate the importance of field-scale tests of this technology to the highest priority level.

Instrument development in FY08 included user commissioning of micro-XRD capability, development of new data acquisition and analysis software tools and significant growth of the user base as well as development of a cryogenic sample stage for grazing-incidence XAS measurements which is the first of its kind in the world. In addition, data analysis packages have been developed for environmental remediation investigations at all U.S. synchrotron facilities. All data analysis programs in below are provided free to the public and are available for download[5].

Chemical Physics of Surfaces and Liquids

The main focus of this research program is to use x-ray and electron spectroscopies to address important questions regarding chemical bonding on surfaces and in aqueous solutions. Photoelectron spectroscopy (PES), XES, XAS and XRS provide an atom specific projection of the electronic structure. Problems related to systems in catalysis, energy technologies, electrochemistry and molecular environmental science experimentally and theoretically using density functional theory (DFT) calculations. Areas of research include the study of molecular adsorbates on surfaces, catalysis, hydrogen storage and water in aqueous systems.

Instrument development is an important part of the activity to provide new spectrometers and enable measurements at high gas pressures and at liquid interfaces. To this end a highly efficient soft x-ray spectrometer optimized for C, N and O K-edges is currently being assembled and a differentially-pumped high-pressure cell using cryogenic technology that can be inserted into this ultra-high vacuum (UHV) system is nearly complete.

Development of Resonant Coherent X-ray Scattering

The research focuses on lensless imaging of the electronic and magnetic properties of nano sized structures at absorption resonances with sub 20 nm resolution. The program has its emphasize on investigating spin and charge order and aims to study stochastic and correlated processes at phase transitions in magnetic nanostructures and correlated materials. Part of the research and development is in preparation for experiments at LCLS starting at the end of 2009.

A variety of techniques has been developed, including (1) Extended Field of View Fourier Transform Holography using spatial multiplexing in Fourier transform holography; (2) Phase imaging using resonant soft x-ray holography; (3) Lensless imaging with multiple-wavelength resonant coherent scattering; and (4) Single-shot compatible characterization of soft x-ray spatial coherence using a non-redundant array of rectangular apertures. This technique is particularly interesting for x-ray free electron lasers (FELs) because of its single shot illumination compatibility.

Small and Wide Angle Scattering Studies of Soft Matter and Colloids

Small angle scattering (SAXS) is an important tool for the study of polymers and nanomaterials.

5 http://www-ssrl.slac.stanford.edu/~swebb

Work carried out in 2008 includes: (1) Drying of Paint – Titania colloidal solutions used in the paint industry are comprised of components including the titania particles, solvents and dispersants. One key issue for the paint industry is that the titania particles tend to agglomerate during dying, which degrades the properties of the final film. In-situ SAXS has been used to study this behavior in titania-based colloidal paints and show how the titania pigment affinic groups influence the aggregation; (2) SAXSFit: A program for fitting SAXS data has been developed to assist in the analysis of nanoparticle or nanopore samples (commonplace in nanotechnology). The program is aimed at novice users and yields the pore or particle size distributions. (3) Anomalous SAXS has been used to measure the particle size and composition distributions in Cu-Pt nanoparticle electrocatalysts (for fuel cells) proving these active catalysts have a core-shell structure. SSRL is recognized as the leader in Anomalous SAXS applications to this important technology.

Structural Properties of Novel and Energy-Related Materials

X-ray diffraction provides an important tool for the study of novel materials and thin films. The work carried out at SSRL during the past year has been extensive requiring that only a few examples of the work be given.

SSRL is the world leader in X-ray scattering from organic films used in thin film transistors (TFTs) and solar cells and we have attracted an extensive user community for such studies. As examples, experiments on organic bulk heterojunction solar cells (blends of a polymer and fullerene) have shown that the orientation of the polymer crystalline domains depends on the solvent used to cast the blend and this orientation has a drastic, but unexpected influence, on solar cell efficiency. For some polymers, an unexpected intercalation between the polymer and fullerene is found, with profound implications of solar cell design. In another example, the polymer pBTTT was developed by Merck with a field effect mobility high enough to be considered useful in practical applications. The precise molecular packing and the microstructure of pBTTT thin films were characterized at SSRL lending important insight into how these influence charge carrier mobility and allowing modeling of the charge transport.

SSRL is also developing an increasing community of physics related research. High resolution diffraction studies of charge density waves (CDW) in rare earth (*R*) tri-tellurides ($R\mathrm{Te}_3$) have show that the transition temperature varies by a remarkable amount (>200 K) across the rare earth series, due to the effect of chemical pressure on the electronic structure. These have also established an unexpected second CDW (with similar magnitude but perpendicular to the first CDW). This has spurred numerous related studies (Angle-Resolved PhotoEmission Spectroscopy [ARPES], Raman, high-pressure).

Transmission X-ray Microscopy (TXM)

The user program on the TXM installed on BL6-2 began in FY08. This instrument provides important new capabilities at SSRL for the study of biological and materials science systems in-situ with 40 nm resolution using hard x-rays. This microscope exploits the advantages of hard x-rays for high resolution imaging and tomography in a wide variety of practical specimens without extensive sample preparation.

X-ray scattering for structural molecular biology and complex materials

SSRL continues to lead non-crystalline x-ray scattering studies in structural biology as the only experimental facility in U.S. fully dedicated for this class of studies. Over two decades of effort in developing a user-friendly facility has attracted a sizable user population in the biology community as well as the soft condensed matter community working on biological and biomedical systems. Recent upgrades to optics and in-hutch instrumentation have enhanced experimental capabilities substantially.

Macromolecular Crystallography

For macromolecular crystallography, advances in instrumentation and beam line technologies continued in FY08. During the FY08 run, six beam lines were in full user operation. This included the new, world-class Gordon and Betty Moore Foundation funded beam line that was designed to address challenging projects such as microcrystals, large complexes and membrane systems. The Stanford Auto-Mounting System (SAM) was available on all of the operational beam lines, incorporating a robot that can mount up to 288 samples without the user having to enter the experimental hutch. SAM operates in an integrated environment that can be used to select and screen samples in a totally automated fashion. Use of the SAM system has been increasing each year since its release in 2003. During FY08, the SAM system was used routinely by more than 85% of the crystallography users. The number of samples screened for diffraction quality with SAM has also been increasing each year. Industrial pharmaceutical users and users from academic institutions and National laboratories, as well as members of the Joint Center for Structural Genomics (JCSG) have screened more than 200,000 crystals to date using the SAM robotic systems, leading to a vast increase in efficiency of the use of beam time and a significant increase in the ability to achieve the highest data quality.

SSRL has also pioneered the use of remote access data collection through which users have the option to conduct diffraction experiments from their home institutions and other remote locations by means of advanced software tools that enable control of the beam lines. Remote experimenters have access to the same tools as local users and have the capability to mount, center and screen crystalline samples and to collect, analyze and backup diffraction data. This remote capability is available on all the macromolecular crystallography beam lines and has been rapidly adopted by the user community, with more than 75% of the user community using this access mode in FY08.

The Uni-Puck universal sample holder was developed through a collaboration initiated by SSRL with the Advanced Light Source (ALS), the Advanced Photon Source (APS), SBC-CAT, CHESS, NSLS and the industrial company, Rigaku-MSC to produce a sample storage container that would be directly compatible with all the sample mounting systems currently in use in the U.S. and many of the systems used abroad. The Uni-Puck was released for use at SSRL at the start of the FY07 experimental run and has been used routinely since then.

XAS Studies as a Probe of Electronic Structure / Contribution to Function

These studies utilize a combination of spectroscopic methods, coupled to DFT calculations, to obtain insight into geometric and electronic structure-function correlations in biologically- and catalytically-relevant systems. A combination of different synchrotron-based spectroscopies is used, including metal K-, ligand K- and metal L-edge XAS and PES. These experiments are carried out on SSRL beam lines 6-2, 7-3, 8-1, 8-2, 9-3 and 10-1.

X-ray Absorption Spectroscopy

BL9-3, the BER-funded beam line dedicated to general user biological XAS, provides extremely high intensity over a broad x-ray energy range, with focused beam from ~4 keV to ~30 keV and is superb internationally competitive bioXAS station, enabling studies of metalloenzyme catalytic centers at μM concentration levels. A unique capability is the recently developed instrumentation for combined XAS and crystallographic measurements, used for polarized measurements to determine specific electronic or bonding characteristics of catalytic centers and to further define active site structures beyond what is possible with macromolecular crystallography. With further developments, the program goals include the in-situ study of reaction intermediates.

User and Staff Awards

Name	Location	Affiliation	Award
Bienenstock, Arthur	Stanford University	SLAC & Stanford University Faculty	Elected a Fellow of the Institute of Physics (Great Britain)
			President, American Physical Society
Brown Jr., Gordon	Stanford University	SLAC & Stanford University Faculty	Hawley Medal of the Mineralogical Association of Canada
			The Association of Environmental Engineering and Science Professors (AEESP) award

Chidsey, Christopher E.D.	Stanford University	SLAC & Stanford University Faculty	2008 elected fellow of the American Association for the Advancement of Science (AAAS)
Cohen, Aina	SLAC	Staff Scientist	President-elect for the Pittsburgh Diffraction Society
Hodgson, K.O.	Stanford University	SLAC & Stanford University Faculty	The Association of Environmental Engineering and Science Professors (AEESP) award
Solomon, Edward I	Stanford University	SLAC & Stanford University Faculty	Bailar Medal, University of Illinois
			Thomas Chemistry Scholar (University of Missouri - Columbia)
			2008 Chakravorty Award and Lecturer, Chemical Research Society of India

Publications in journals outside the field indicating significant impact

- *Nanoparticles: A Golden Close-Up*, Crystal structure of a gold-thiolate cluster reveals surprising surface chemistry, Bethany Halford, Chemical & Engineering News, October 22, 2007 Volume 85, Number 43 p. 13
- *Archimedes brought to light*, Physics World, 20, No 11, pp. 39-42, (November 2007).
- *Physicists shine light on the human brain*[6], *symmetry Magazine*, September 2008,
- *Hundreds of Dino-Era Animals in Amber Revealed by X-Ray*[7], National Geographic, April 2008.
- *Fermilab lecture looks at works of Archimedes*[8], Daily Herald, September 2007
- Science News highlighted article "*Hydrogen Storage in Carbon Nanotubes through the Formation of Stable C-H Bonds*" published in Nano Letters, 8 (1), 162 -167, 2008 by Nikitin *et al.*
- *The March of the Carbon Nanotubes*[9], Nanotechnology Now, March 4, 2008
- *The March of the Carbon Nanotubes*[10], Nanotechwire, March 5, 2008
- *New carbon nanotube hydrogen storage results surpass Freedom Car requirements*[11], Nanowerk, January 21, 2008

NOTEWORTHY PRACTICES

Enhanced Non-crystalline X-ray Scattering and Diffraction Facility

Beam line 4-2 received extensive upgrades on optics and in-hutch instrumentation in FY08. This facility primarily supports the structural biology community working on weakly scattering low-Z materials as well as time-resolved studies. Blu-Ice based experimental control and advanced x-ray detectors provide high-throughput data collection capabilities in line with the substantially improved beam characteristics while enabling flexible instrument configuration with an array of sample handling devices.

Molecular Environmental and Interface Science

The development of a new DOE-BER National Lab SFA research center was an important milestone in furthering the impact of the SSRL MES program on important national priorities.

Development of Resonant Coherent X-ray Scattering

A number of innovative techniques for lensless imaging of the electronic and magnetic properties of

6 http://www.symmetrymagazine.org/breaking/2008/08/21/physicists-shine-some-light-on-the-brain/
7 http://news.nationalgeographic.com/news/2008/04/080404-amber-animals.html
8 http://www.dailyherald.com/story/?id=44889
9 http://www.nanotech-now.com/news.cgi?story_id=28315
10 http://nanotechwire.com/news.asp?nid=5625
11 http://www.nanowerk.com/spotlight/spotid=4154.php

nano sized structures have been developed which will not only be state-of-the-art techniques for SPEAR3 but will also be transferable to the LCLS.

Scientific Support Programs at SSRL

The scientific support in all the different research areas at SSRL (including molecular environmental science, materials and chemical science and structural molecular biology) are integrated into the user operations in such a way that developments by the scientific staff are rapidly deployed into the user program.

Rapid Scan X-ray Fluorescence Imaging

This development used a novel combination of field programmable gate array technology in combination with the standard SSRL computer control system to yield a very efficient system for performing rapid scan x-ray fluorescence. This has empowered research in both large samples as well high-resolution microprobe experiments.

Macromolecular Crystallography

The macromolecular crystallography program has developed an integrated automation system that allows for fully remote instrument control and data taking. The Blu-Ice user software interface has been adopted as a standard by many of the synchrotron radiation laboratories in the world. The Uni-Puck developments have made sample exchange between laboratories practical, further improving the productivity of users.

OPPORTUNITIES FOR IMPROVEMENT

Advances in X-ray Diffraction Capabilities

The x-ray diffraction capabilities at SSRL could be greatly advanced by the use of large area detectors in conjunction with the diffractometers. A plan was developed last year, but the lack of funding will require a slower, more graded approach to reach some of the goals.

Small and Wide Angle Scattering Studies of Soft Matter and Colloids

Small angle scattering research focusing on materials science at SSRL could be significantly improved with a tunable source that fully utilizes the high brightness capabilities of SPEAR3.

New Beam Lines

New capabilities for RIXS, XES and XRS would be realized with the addition of a new hard x-ray undulator beam line. With the high brightness of such a beam line, state-of-the-art capabilities in these fields would be made available when coupled to the Inelastic Scattering and Advanced Spectroscopy Facility described above. A second high brightness beam line has been identified as a high priority for a nano-probe with applications in molecular environmental, materials and chemical sciences.

Objective 1.2 Leadership in Science and Technology

The SSRL component of the Photon Science faculty and SSRL staff are leaders in the international community as seen in the list of advisory and review committees on which they serve and the R&D projects undertaken by SSRL staff.

Bargar, John

- Member, ALS environmental proposal review panel
- Secretary of EnviroSync

Bergmann, Uwe

- Invited by the BES Advisory Committee “New Era” subcommittee as a Science Opportunity Speaker, October 27-28, 2008
- Member, LCLS design review, K-Monochromator
- Chair, Mini-symposium “Complementary Low-Z Element Absorption Spectroscopy by X-ray Raman Scattering” at IUCr2008, Osaka, Japan, August 30, 2008

Bienenstock, Arthur

- Member and Executive Committee, National Academy of Science Committee on Science, Technology and Law
- Member, National Academy Committee on Science and Security

Brennan, Sean

- Member, NSLS-II Conceptual Design (CD, Lehman) Review Panel
- Chair, APS proposal review panel on Applied Materials Scattering
- Member, LCLS review panel for diagnostics hardware
- Member, DOE BES Facilities Program Review Committee for the APS, Argonne National Laboratory (ANL)

Corbett, Jeff

- Australian Synchrotron International Machine Advisory Committee
- Center for Advanced Microstructures and Devices (CAMD) Synchrotron Machine Advisory Committee

Deacon, Ashley

- Chair, Resource Advisory Committee for the Northeastern Collaborative Access Team (NE-CAT) at APS

DeBeer George, Serena

- APS spectroscopy proposal review panel

Hedman, Britt

- Member, BioCAT Advisory Committee, APS, ANL
- Member, National Institutes of Health (NIH) National Center for Research Resources (NCRR) Special Study Section Site Visit Team for NCRR Research Resource
- Member, International Review Committee for The Danish National Program for Research Infrastructure
- Member, DOE BES Facilities Program Review Committee for the APS, ANL

Hettel, Robert

- NSLS Scientific Advisory Committee (SAC)
- Chair of NSLS-II Stability Workshop
- Member, NSLS-II Lehman Review Committee and chair, Injector Systems sub-committee
- Member, Beijing Electron Positron Collider Upgrade (BEPC-II) International Machine Advisory Committee (MAC), IHEP, Beijing
- Member, Taiwan Photon Source MAC
- Advisor Professor for the Shanghai Synchrotron Radiation Facility
- Member, Organizing and Program Committee, U.S. Beam Instrumentation Workshop

Hodgson, Keith

- Member of the International Advisory Committee for the Oxford Protein Production Facility, Oxford
- Member and Chair, Photon Factory International SAC, Tsukuba, Japan
- Member, National Synchrotron Radiation Research Center (NSRRC) Light Source International Advisory Committee, Hsinchu, Taiwan
- Member, Resource Advisory Committee for the NE-CAT at APS

Ohldag, Hendrik

- Chair, ALS Users' Executive Committee

- Ex-officio member of the ALS SAC
- Member search committee ALS scientific director
- Member hiring committee ALS user support group leader
- Member ALS doctoral research fellowship committee
- Member of the ALS proposal reviewer pool

Pianetta, Piero

- SAC, APS
- SAC, Canadian Light Source
- SAC, National Center for X-ray Tomography, Lawrence Berkeley National Laboratory (LBNL)
- Member, DOE Triennial BER review panel for Environmental Molecular Sciences Laboratory (EMSL)
- Member, NSLS-II CD (Lehman) Review Panel
- International Advisory Committee, Total Reflection X-Ray Fluorescence (TXRF) Conference

Pople, John

- Proposal review panel National Institute of Standards and Technology (NIST) Neutron Facility

Rabedeau, Thomas

- NSLS-II Director's Construction Readiness Design Review
- LCLS Facilities Advisory Committee
- National Institute of Biomedical Imaging and Bioengineering (NIBIB) P41 Review of CASE Center for Synchrotron Biosciences
- LCLS Ultrafast Science Instruments (LUSI) Director's CD-2 Readiness Review
- LCLS Facilities Advisory Committee

Schimberg, John

- Member, Program Committee, Free Electron Laser (FEL) Conference

Solomon, Edward

- Associate Editor, *Inorganic Chemistry*

Soltis, Michael

- Member, review committee for the macromolecular crystallography beam lines at the APS (IMCA-CAT and SGX-CAT)
- Member, review committee for the European Synchrotron Radiation Facility (ESRF, BM14)

Stöhr, Jo

- SAC, Center for Nanophase Materials Sciences, Oak Ridge National Laboratory (ORNL)

Toney, Michael

- Member, NIST Center for Neutron Research Beam Time Allocation Committee
- Chair, APS Scattering Applied Materials Proposal Review Panel (PRP)
- Co-chair, Materials Research Society Symposium on "Materials in Transition-Insights from Synchrotron and Neutron Sources"
- Member, Science Team for Surfaces, Interfaces and Thin Films for the APS upgrade
- Member, review committee for the LCLS K-Measurement Monochromator System

Tsuruta, Hiro

- Member, General User Proposal Review Panel in small angle scattering for the APS
- Co-authored the "Small/Wide-Angle X-ray Scattering" section of the NSLS Scientific Strategic Planning Workshop Summary

- Member, NSLS Beam Line Review Committee
- Member, EMBL@Petra3 (European Molecular Biology Laboratory Hamburg Outstation Petra-III project) scientific advisory board
- Invited to attend and speak at the NSLS-II life science workshops

Wiedemann, Helmut

- Chairman, Machine Advisory Committee, 3 GeV Taiwan Photon Source (TPS)
- Member, International Advisory Committee, Pohang Light Source (PLS)

Winick, Herman

- Member, SAC for CAMD
- Member, Outside Review Committee for Synchrotron Radiation Center (SRC) in Wisconsin
- Member, Beam line Advisory Committee for SESAME
- Member, International Scientific Advisory Committee (ISAC) for the National Center for Physics of Pakistan
- Member of the Committee on International Scientific Affairs (CISA) of the American Physical Society and Past Chair of its Forum on International Physics (FIP).

Areas which show SSRL's leadership in science and technology are described below.

PEP-X R&D Program

The physical size (circumference) of SPEAR3 constitutes a barrier to upgrading it to achieve significantly higher brightness, which is required for the study of complex materials on the nanoscale, in combination with time and energy resolved measurements. Therefore, we are developing plans for a higher-performing x-ray source, PEP-X. PEP-X is based on the development of an existing large storage ring (2.2 km circumference) on the SLAC site, PEP-II, into an x-ray source which produces x-rays with an average brightness that exceeds any other storage ring light source, existing or planned, by more than a factor of 10 and SPEAR3 by more than a factor of 1000.

Training of Accelerator Physicists

The SSRL accelerator physics group has participated in teaching a large number of accelerator training classes. This is a very important contribution to the field and has included:

1. Light Source Accelerator Physics, James Safranek, Joint Accelerator School, Indore, India, January 14-18, 2008
2. High Brightness Electron Injectors for Light Sources, John Schmerge, David Dowell and Steve Lidia, U.S. Particle Accelerator School (USPAS), Santa Rosa, California, January 14-18, 2008
3. Beam Diagnostics Using Synchrotron Radiation: Theory and Practice, Jeff Corbett, Alan Fisher and Walter Mok, USPAS, Santa Rosa, California, January 14-18, 2008
4. Response Matrix Analysis: Applications to Accelerator Orbit Control, Optics Diagnostics and Correction, Andrei Terebilo, USPAS, Santa Rosa, California, January 21-25, 2008
5. Beam-Based Diagnostics, James Safranek and Christoph Steier, USPAS, Annapolis, Maryland, June 16-20, 2008

Development of Research Using Circularly Polarized Radiation

SSRL has installed a new beam line (BL13) to provide circularly polarized radiation for programs in chemical physics of surfaces and liquids, the resonant coherent x-ray scattering and scanning tunneling microscopy of magnetic films. Last year, vendor problems with the undulator required the use of an existing undulator from BL5 that also produces circularly polarized x-rays, although over a narrower energy range than what will ultimately be desired. The decision proved to be correct since the BL5 undulator has performed very well over the past year. This decision has allowed the beam line to run successfully for the whole year while the issues with the new undulator are being rectified.

Molecular Environmental and Interface Science (MEIS)

SSRL continues to be a world leader in the field of MEIS by significantly contributing to the beginning of the field as well as continuing to the present with a growing user community that takes advantage of existing beam lines (such as BL11-2, 7-2, 10-2 and 2-3), new beam lines such as BL4-1 and a future beam line for nano- focusing spectroscopy that will be proposed within the next year.

Development of Resonant Coherent X-ray Scattering

This is an area that has the potential for high risk and high reward. Current developments include methods of imaging magnetic systems using Fourier transform holography techniques as well as ways of improving the signal to noise of this method using multiple scattering points. BL13 has given this facility a permanent home that has enabled development of a wide variety of lensless imaging techniques that will not only put the field forward in the short term but will also be a testing ground for techniques that will be used at LCLS.

XAS for Structural Molecular Biology (SMB) and Material/Chemical Sciences

SSRL has a world class XAS program that serves both an external and internal user community and receives high marks in external peer reviews. The research quality depends on developments by SSRL staff in beam line stability, sample environments and detector developments. These new capabilities have continued with the development of single crystal XAS that has added the capability of using the polarization of the beam to highlight particular bonds and determine their structure. The research has become routine during the past year and is producing exciting research results.

Outreach, Training and Planning for Future Research

SSRL provides training and outreach for users through workshops held at the annual SSRL user meeting and throughout the year. Such workshops include the "SSRL School on Synchrotron X-ray Absorption Spectroscopy Techniques in Environmental and Materials Sciences: Theory and Application" (May 2008) and the "Stanford-Berkeley Summer School on Synchrotron Radiation" (August 2008).

NOTEWORTHY PRACTICES

Outreach, Training and Planning for Future Research

Workshops provide training to users in the effective use of SSRL beam lines resulting in more efficient use of beam time as well as introducing new users to the capabilities of SSRL. In addition, the training of accelerator physicists is an important activity that contributes to the entire community.

Top-off Tracking Studies

We are close to completing comprehensive top-off injection computer simulations. Through these simulations, we have determined a set of magnet strength interlocks that will guarantee the safety of top-off injection. The computer algorithms developed at SSRL are already being used as a model for top-off tracking studies at NSLS-II and in Taiwan.

Molecular Environmental and Interface Science (MEIS)

A under the lead principal investigatorship of a SSRL senior staff scientist, a new DOE-BER-funded National Lab SFA research center was created to study the structure/property relationships and environmental geochemical dynamics of complex nano-materials, with emphasis on biogenic uraninite and iron oxides. This multi-institution project includes two co-principal investigators from Stanford, nine other investigators from DOE laboratories, the U.S. Geological Survey and academic institutions. This project will leverage SSRL capabilities to elucidate the fundamental processes and materials that underpin environmental remediation science and will facilitate the closure of contaminated DOE sites.

XAS for Structural Molecular Biology (SMB) and Material/Chemical Sciences

Development of a world-class NIH and DOE BER funded user program focused on SMB expands and supplements the DOE BES funded user operations activity. This program receives very high marks in external peer reviews as well as from user feedback and is a leader in XAS, SAXS and macromolecular crystallography operations and research.

Materials and Chemical Science Research

Exciting research results continue to be generated within this program at SSRL. These are more fully described in the SSRL science highlights for 2008[4]. Examples showing SSRL leadership in this broad field include novel imaging methodologies in the areas of:

- Coherent imaging (*Lensless MAD Imaging of Nonperiodic Nanostructures, Panoramic Holography: Toward a Single Shot Stopwatch*)
- The structure of water (*More Evidence for a Revolutionary Theory of Water*)
- The structure of condensed matter (*Electronic Structure of LaOFeP - a Different Type of High Temperature Superconductor*)
- Novel materials/technology (*Understanding Thin Film Structure for the Rational Design of High-Performance Organic Semiconductors for Plastic Electronics*)
- The Sub Picosecond Pulsed Source (SPPS) experiment (*X-ray Diffuse Scattering Measurements of Nucleation Dynamics at Femtosecond Resolution*).

Opportunities for Improvement

Development of New and Unique Research Capabilities

DOE reviews and the SSRL SAC have uniformly praised SSRL but it has often been noted that the staff is stretched. Although SSRL optimizes the efficient use of its beam lines, the inability to hire new staff has hampered SSRL's ability to fully exploit the capabilities of SPEAR3 and threatens its long-term viability as a leading center for synchrotron based research.

X-Ray Microscopy

The user community for the new transmission x-ray microscope is growing. With proper outreach, SSRL has the opportunity to develop new areas of research in materials science, environmental science and biology.

X-Ray Diffraction and Scattering

Development of new capabilities requiring 2D detectors and new sample environments will be instrumental in developing a leadership role in the area of x-ray diffraction and scattering.

Objective 1.3 Provide and sustain Science and Technology Outputs that Advance Program Objectives and Goals

SSRL research output can be measured in the number of publications by staff and users and the invited talks by staff. In 2007, the total was 336 publications and 20 PhD theses. As of this writing, the partial list for 2008 yields 292 publications and two theses. As was the case for FY07, the numbers for 2008 are expected to grow as publication data continues to be collected beyond the close of FY08. The number of invited talks by the relatively small SSRL staff was 79. Publications for 2007, 2008 and the invited talks are included in the Publication Appendix[3].

Objective 1.4 Provide for Effective Delivery of Science and Technology

Inelastic Scattering and Advanced Spectroscopy Facility for SPEAR3

To reduce the set up time for the x-ray emission spectroscopy apparatus, the BL6-2 hutch usage was reviewed and the decision was made to reconfigure the hutches so that this system could be permanently located in the middle hutch. This will greatly reduce the set up time and allow for faster user turnover.

Scientific Support Programs at SSRL

Use of unified software and hardware platforms for beam lines that support the same applications, leveraged the relatively small scientific staff to provide excellent research output and user support. There is an effort underway to reconfigure the diffraction beam line with new control software that will be the same as will be used at LCLS and other synchrotron labs. This will further simplify user training.

SPEAR3 Improvements

Increased attention is being focused on the stability of the electron beam in SPEAR3. We have partnered with the SLAC alignment group to install additional diagnostics to monitor height variations in the SPEAR3 tunnel floor and we are painting the tunnel roof white. This work should help us understand and reduce slow electron beam motion. In addition, we have made significant progress toward implementing top-off injection. With top-off injection we will inject beam into SPEAR3 with the photon shutters open, which will greatly reduce thermal transients on photon beam line optics, improve beam line stability and increase usable beam time. Eventually we plan to switch from injecting three times per day to injecting approximately once per minute, which will further improve photon optics stability and increase integrated photon flux.

Molecular Environmental Science

The micro-XAS capabilities developed and commissioned in 2007 on BL2-3 have proven to be a great success. The apparatus is being permanently installed on the beam line and the superb data collection and analysis package provides a very fast learning curve to users and will be propagated to other beam lines with imaging capabilities.

XAS Studies

SSRL has been able to leverage the BES, BER and NIH programs to supply state-of-the-art capabilities for XAS in fields ranging from biology to materials science. This includes state-of-the-art detector systems, single crystal XAS capabilities (a world-wide unique facility) and microprobe/imaging capabilities. SSRL maintains world-class capabilities in XAS including the study of dilute systems.

NOTEWORTHY PRACTICES

SPEAR3 Improvements

We have installed a system of radiation monitors to ensure that we minimize radiation at the beam lines during top-off injection. We have commissioned electronics for our injector transport line beam position monitors (BPMs), which have led to much improved control of the trajectory and optics of the injected beam arriving at SPEAR. These improvements led to improved injection rates and reduction in radiation during top-off injection. We have also developed our SPEAR beam position monitor (BPM) and synchrotron light monitor (SLM) systems to further characterize and improve our injected beam.

Scientific Support Programs at SSRL

Leveraging common hardware and software platforms allows for efficient user support and user training.

Recognition of SSRL Scientific Programs by DOE BES Review

SSRL's delivery of science and technology is also demonstrated by comments from the successful 2008 triennial review in which Pedro Montano writes in his transmittal letter of May 21, 2008[1]: "*SPEAR3 has performed superbly with high reliability and infrequent faults. The SPEAR3 upgrade produced a beam brightness approaching those of the other BES third generation light sources, ALS and APS. There is a high level of scientific productivity with world-class science being carried out in a number of areas.*"

OPPORTUNITIES FOR IMPROVEMENT

Micro-XAS and Micro-Fluorescence Capabilities

Several different microfluorescence capabilities are being developed at SSRL. There is an opportunity to unify the hardware as well as data collection software between the different beam lines to improve efficiency and the ability of users to work on the different beam lines without additional training.

Advanced Detectors for XAS and Diffraction

One of the limitations of many of the experiments being done at SSRL is the detector. The addition of advanced detectors with higher throughput for XAS will greatly improve detection limits and signal to noise. In addition, the use of charge control device (CCD) or pixel array detectors for diffraction will improve throughput and allow for in-situ studies of time dependent processes.

B ➤ Linac Coherent Light Source (LCLS)

The LCLS x-ray free-electron laser (XFEL) facility will enable new science by providing x-ray pulses of unprecedented peak power and brightness. The facility is currently under construction, with initial operation planned for late FY09. In addition to the main LCLS construction project, an major item of equipment (MIE) project called LUSI is in the early stages of creating additional scientific end stations for the LCLS facility.

As a unique scientific resource, the LCLS will be in high demand from a world-wide scientific community. SLAC is making every effort to assure the timely completion of construction and the efficient and productive operation of this new facility. Specifically, in FY08 SLAC has carefully managed the ongoing construction work, revised the management structure of the LCLS directorate to expedite the transition of LCLS from a construction project to operating facility and has engaged the scientific community to help ensure successful experiments.

The LCLS directorate at SLAC has put management of the LCLS construction and LUSI projects in a common division. Responsibility for operation of the SLAC linear accelerator was brought within the LCLS Accelerator Systems Division (ASD) in FY08. A new Experimental Facilities Division (EFD) has been created to operate the LCLS x-ray experimental systems and manage user research.

During electron beam commissioning in FY08, the full LCLS accelerator system met or exceeded all of its goals. This is a major milestone toward the realization of a linac-based XFEL. The LCLS injector remains the brightest FEL injector in the world. Interest in this accomplishment has been demonstrated through invited talks at major international conferences and offers to participate in the LCLS commissioning effort.

Objective 1.1 Science and Technology Results Provide Meaningful Impact on the Field

Stewardship of Mission-Relevant Research Areas

- The FY08 commissioning of the electron linac was very successful
- The electron beam quality routinely meets specifications for LCLS FEL operations

NOTEWORTHY PRACTICES

- Early commissioning of the LCLS accelerator provides extensive pre-operational experience
- Diagnostics and methods attract attention from the international XFEL community
- FY08 commissioning included representatives from DESY, Sincrotrone Trieste and Spring-8

OPPORTUNITIES FOR IMPROVEMENT

- Need to record and publish details of machine design and results of initial operation
- Continue to establish ultrafast science as a robust core competency at SLAC

Objective 1.2 Leadership in Science and Technology

Novel Approaches and Innovation

- Due to its groundbreaking nature, many of the LCLS systems are quite innovative. The success of some of these innovations is demonstrated by the performance of the LCLS accelerator

Collaborative Efforts

- A three-way international collaboration between LCLS, DESY and Spring-8 has been formed to explore technical challenges common to the collaborators' FEL designs

Leadership of LCLS Staff

- LCLS staff members serve on advisory committees for light sources around the world such as the Swiss Light Source, the European Synchrotron Radiation Facility, the PLS and NSLS-II

NOTEWORTHY PRACTICES

- LCLS seeks out advice through international workshops and design reviews
- LCLS commissioning effort includes top scientists from other FEL facilities

OPPORTUNITIES FOR IMPROVEMENT

- LCLS must continue to attract and maintain a top-quality scientific staff as it moves from construction to scientific operations

Objective 1.3 Provide and sustain Science and Technology Outputs that Advance Program Objectives and Goals

- Invited talks and papers on LCLS development were presented at the FEL, Experimental Program Advisory Committee (EPAC) and Linac conferences
- LCLS published four peer-reviewed journal articles in FY08[3]
- Klystron/Microwave Department (KMD) built 14 5045 klystrons to support linac operations

NOTEWORTHY PRACTICES

- LCLS SAC meets semi-annually
- LCLS responds formally to SAC review recommendations
- Created EFD to manage user research program
- Performed major upgrades to the accelerator structure test area (ASTA) test bunker to bring S-band RF power allowing the test of a spare RF gun for the LCLS injector

OPPORTUNITIES FOR IMPROVEMENT

- Coordinated effort across all the collaborating institutions needed to record details of LCLS technical systems

Objective 1.4 Provide for Effective Delivery of Science and Technology

Effectiveness in Meeting Goals

- Major project milestones completed on time
- Commissioning of the LCLS linac was completed ahead of schedule
- Performance of the commissioned portions of the facility have exceeded design goals
- KMD provided key personnel to change the RF probes on the LCLS RF gun with great success
- KMD provided key personnel for a quick turnaround cathode change for the LCLS RF gun leading to a much better quantum efficiency than the previous cathode

Transmitting Results

- Commissioning results presented at international conferences
- Performance guidelines based on commissioning results communicated to user community

NOTEWORTHY PRACTICES

- LCLS has been able to adapt to BES-directed changes without major compromises in project scope
- KMD took over ownership of the cathode qualifying system and began repair work to support future LCLS cathode research

OPPORTUNITIES FOR IMPROVEMENT

- Early science goal will require efficient coordination of accelerator operations, beam commissioning and instrument installation

C ➤ Photon Ultrafast Laser Science and Engineering (PULSE)

Objective 1.1 Science and Technology Results Provide Meaningful Impact on the Field

The main mission of the PULSE center is to conduct research in ultrafast science which supports the research program of the LCLS and SPEAR3. A wide range of experiments probing ultrafast dynamics in chemistry, materials science, atomic, molecular and optical (AMO) physics and structural biology, have recently begun and, as shown by the FY08 publications list, are already showing important results which will inform the first experiments to be carried out at the LCLS.

PULSE is pioneering the new technique of nonperiodic imaging through coherent diffraction. This “single particle imaging” has been performed with cells, nanoparticles, viruses, encapsulated biomolecules, carbon nanotubes, making good use of the coherent soft x-rays available at FLASH (Free-electron LASer in Hamburg). We’ve also done damage experiments, with optical pumps and x-ray probes; massively parallel x-ray holography; and femtosecond time-delayed x-ray holography.

In a separate collaboration between PULSE and colleagues in Germany, we have done work in materials interactions with soft x-rays. We have demonstrated the feasibility of x-ray absorption spectroscopy at FEL’s, which will lead to an important new application for FEL x-ray radiation. These experiments will greatly assist in the development and success of the LCLS program, providing access to similar x-ray intensities at soft x-ray wavelengths.

In another collaborative activity within the PULSE Institute, we set up a project directed at producing attosecond pulses in the extreme ultraviolet. This will have a significant impact on future attosecond operational modes at the LCLS, associated with enhanced self amplified spontaneous emission and the use of carrier-envelope phase stabilized lasers to control the LCLS pulse shape.

We demonstrated the role of multiple orbitals in high harmonic generation (HHG). This creates new opportunities to monitor the dynamics of electrons in molecules. We developed a new methodology for the study of electronic structure in strong fields and have discovered and studied shape resonances, especially the change of continuum structure in atoms.

At SPEAR3, we’ve developed a new high rep rate ultrafast capability and carried out the first experiments probing nanoscale dynamics, which will eventually use the unique capabilities of SPEAR3, including low-alpha mode. We’ve looked at ferroelectric nanocrystals with hard x-ray microprobe radiation and used soft x-rays to probe magnetic materials and the structure of water.

In laser laboratory research in the PULSE Institute laboratories, we have also developed THz strong field sources for probing and controlling electronic processes in solids and we have observed new nonlinear THz-induced effects. These will complement THz capabilities at LCLS that could be developed within the next decade.

Multidimensional Vibrational Spectroscopy: During FY08 we installed and commissioned a laser system designed to do multi-dimensional vibrational spectroscopy. Such capability exists in roughly half a dozen laboratories within the U.S. and a similar number of laboratories in the rest of the world. We have recently submitted our first manuscript using this experimental capability.

Femtosecond Resolution Transient Absorption: During FY08 we installed and are currently completing the commissioning of a laser system designed to measure the changes in visible and near IR absorption induced in a sample by laser excitation. This facility will be used to investigate photochemical dynamics and will be central to validating and preparing for experiments at the LCLS.

NOTEWORTHY PRACTICES

PULSE researchers have worked in research areas designed to enhance the value of LCLS. For example, a single particle injector has been perfected in our collaboration and is used at FLASH, which is the prototype for several other instruments coming on line, such as:

- LCLS soft x-ray end station
- Fermi at the Elettra Laboratory in Trieste
- Coherent x-ray imaging (CXI) end station at LCLS

PULSE is directly involved in the design, testing and construction of these instruments.

Thz pulse generation techniques have been advanced that can be used in other laboratories and eventually at FEL's.

New HHG experimental techniques permit more precise probing of electron structure and dynamics in molecules.

New 3D alignment techniques in molecules will lead to novel targets of aligned molecules and nanoparticles through coherent control of quantum rotational motion.

PULSE has an impact on the design of many of the LCLS end stations.

Using Stanford funds, we have held a successful seed competition for new ideas. Seed funding will stimulate science in areas directly related to early experiments on LCLS.

OPPORTUNITIES FOR IMPROVEMENT

PULSE will occupy new laboratories beginning in mid-to-late FY09 that will provide a better colocation and research collaboration across the institute. LCLS will turn on this year and focus much of our activities. PULSE has major activities in all LCLS research instrument areas.

Objective 1.2 Leadership in Science and Technology

PULSE has lead or co-lead many of the major proposals and strategic direction activities at SLAC this year. This includes:

- Co-leading the x-ray pump probe (XPP) instrument development team; work on the SLAC business plan; leadership of the SLAC-LBNL collaboration on the future of x-ray science
- Co-leadership of LCLS-2 and PEP-X planning
- PULSE
    - Organizes and runs the very successful Ultrafast X-ray Summer School
    - Led the formation of working groups to help launch the LCLS experimental campaign.
    - Conducted a joint retreat with LCLS, which led to a closer research connection.
    - Participated in two of the three energy frontier research center (EFRC) proposals submitted by Stanford.
    - In conjunction with SLAC Photon Science and SU departments, successfully recruited two outstanding leaders in the areas of ultrafast x-ray diffraction and in excited state dynamics– both very relevant to LCLS science

NOTEWORTHY PRACTICES

- PULSE conducts a seminar series and participates in the SLAC instrument seminar series, linking different research activities of the Stanford and SLAC communities
- PULSE members have leadership roles in major scientific meetings

Objective 1.3 Provide and sustain Science and Technology Outputs that Advance Program Objectives and Goals

PULSE faculty and scientific staff members were major participants in the process that led the establishment of grand challenge goals in energy science for BES.

The PULSE Institute researchers published approximately 25 research papers and were invited to give more than 50 presentations at laboratories, universities and international meetings this year[3].

DOE sponsored research exceeded $4M this year.

PULSE participated with LCLS on design of the baseline instruments and assisted in the strategy to begin an active and sustained world-leading research program through proposal writing workshops and the Ultrafast X-ray Summer School. PULSE has also spent considerable effort this year building towards a sustained research future through participation in EFRC grants and single-investigator and small-group research (SISGR) grants for BES and by writing several user research proposals for LCLS.

Noteworthy Practices

To enhance our science output, PULSE is encouraging collaborative activities and focusing on grand challenge energy research.

Objective 1.4 Provide for Effective Delivery of Science and Technology

Bogan Lab

We developed plans for early occupancy of the PULSE building, working closely with the architect, the renovation project team and our international collaboration. We are in temporary space in B137 for program activities prior to occupying the first PULSE Institute space, which will be ready in FY09. Meanwhile, we have continued laboratory work at Lawrence Livermore National Laboratory (LLNL) that will transition to PULSE building in the next year.

Coffee/Bucksbaum Lab

We installed, commissioned and are using a complete kHz laser system that gives us similar performance to the laser that will be available at the AMO instrument for LCLS. We helped design the new optics labs in the PULSE Institute. We are designing a “replica” of the LCLS AMO instrument to facilitate rapid science transfer from the lab to LCLS.

Lindenberg Lab

Our second laboratory was commissioned in newly renovated laboratory space in the SU Durand building for materials science engineering. We installed and commissioned a new high repetition rate laser for use at SPEAR3. We developed new capabilities in our B130 laboratory, notably the THz pulse generation referenced above.

Guehr/Bucksbaum Lab

In collaboration with the LCLS laser group (White), we upgraded our basic carrier-envelope-phase (CEP) stabilized laser system to provide a second beam line with improved energy. We designed a new chamber and spectrometer to accommodate reactive gases, which will be critical for attosecond dynamics measurements. Our HHG work has revealed important new research results.

Acremann/Stöhr Lab

We led the team that is designing the soft x-ray end station at LCLS. In addition, we developed a new Mott detector that can provide electron spin-detection at LCLS for magnetic dynamics and spectroscopy measurements.

Gaffney Lab

We have made significant progress on the commissioning of an ultrafast spectroscopy laboratory. We completed a multidimensional vibrational spectroscopy set-up and submitted our first paper for publication in this area. We have a femtosecond resolution transient absorption facility for measurements in the visible and near IR and currently commissioning the facility. We established a research program in resonant inelastic x-ray scattering for studying sub-femtosecond electron dynamics and have submitted our first manuscript in this area.

D ➤ Stanford Institute for Materials and Energy Science (SIMES)

Objective 1.1 Science and Technology Results Provide Meaningful Impact on the Field

SIMES faculty and staff have research carried out extensive experiments and theoretical investigations on its scientific core areas:

- X-ray science and techniques
- Quantum materials
- Carbon based and biomimetic hybrid materials

- Interface and catalysis

Quantum materials portfolio correlates materials, superconductors and magnetic materials. These materials are central to some of the BES goals in its "grand scientific challenges." We synthesized and characterized a number of novel materials that have enabled important discoveries. Notable two novel superconductors that led to important insights–the newly discovered Fe-Pnicide and highest Tc cuprate Hg based superconductor. On the measurement side, we performed experiments using high precision photoelectron spectroscopy, scattering and local probe imaging experiments to address some of the most pressing problems in the field. On the theory side, a balanced approach using both analytical and computational techniques towards complex and magnetic materials has been carried out with a number of breakthroughs.

SIMES continued to play an active role in advancing the research agenda to understand novel material properties at the organic and in-organic interfaces and on carbon based and biomimetric hybrid materials. In particular, recent work on diamondoids has attracted considerable attention and led to potential new technologies.

SIMES pioneered the development and application of a number of important x-ray techniques and computational capabilities to enhance the value of these x-ray techniques. In particular, SIMES has played an important role in forming a consortium for an instrument operating in the soft x-ray regime to use LCLS. When implemented, this instrument will enrich LCLS science with a wide spectrum of experiments planned, complementing the instruments being funded by DOE BES. SIMES has also performed pioneering time and angle-resolved photoemission experiments.

SIMES research has lead to the discovery of a new fuel cell catalyst for the oxygen reduction reaction. It is based on an electrochemical leached PtCu alloyed catalyst where the Pt on the surface is left in a strained configuration with five times higher activity than pure Pt. This catalyst is currently the most active as tested in a real fuel cell and is attracting major interest from the automobile industry.

NOTEWORTHY PRACTICES

The result of one of our programs, quantum spin Hall effect, was recognized as one of the ten most important scientific breakthroughs by *Science*.

This year SIMES had important publications in scientific journals including *Science* (2) and *Nature* (3). The fabrication of two novel superconductors led to two papers in *Nature* with experiments using neutron scattering and photoemission. Another angle-resolved photoemission experiment led to publication in *Nature* revealing the presence of two competing states in cuprate superconductors. The pioneering angle and time resolved photoemission experiment led to publication in *Science*. Investigations of nano-diamond led to a publication in *Science* on new insights on the nature of monochromatized electron emission from novel surfaces.

An important high pressure experimental program has been added that will be used to study novel materials under extreme pressure.

Using Stanford funds, we have held a successful seed competition for new ideas. With the support of a BES peer review process, one of the teams on bio-materials now receives seed funding from BES.

SIMES has attracted a large number of talented young people to the program.

Several U.S. patent disclosures and filings occurred this year, most notably:

- Diamondoid monolayers as electron emitters
- Direct band gap diamondoid devices
- Photoemission enhanced thermionic emission for solar energy harvesting
- New fuel cell catalyst

OPPORTUNITIES FOR IMPROVEMENT

SIMES needs high quality, contiguous space to facilitate its growth at SLAC and its interactions with other researchers. More effort is needed to broaden the scope of our program, for example, into biomimetric and nanomaterials areas.

Objective 1.2 Leadership in Science and Technology

The research carried out at SIMES is of very high quality. This is reflected by its capitalization of the intellectual resources at SU into its staff, its strategic role in the development of the photon mission at SLAC, the high number of publications in the seminal journals of our research, the citation index and technical media coverage. This is also reflected in the fact that young people trained in SIMES are highly sought after individuals by other institutions.

SIMES retained productive and quality scientists for its leadership. SIMES leadership are internationally recognized in their respective fields of expertise. Shen is a leader in developing photoemission spectroscopy and its application to complex materials while Nilsson is a leader in x-ray absorption, emission and core level photoemission expert, with emphasis on applications in surface/interface chemistry.

NOTEWORTHY PRACTICES

- Recognition of SIMES results and identification of SIMES work as a breakthrough by *Science* magazine.
- Publications in high quality journals, for example the five papers in *Nature* and *Science*.
- Important fellowships and career opportunities for young people trained through SIMES program.
- Impact on the technology community from basic research in SIMES—interest from industry (e.g., Chevron and General Motors) and research institutes (GCEP, funded by GE, Exxon, Toyota and Schlumberger) based on basic research at SIMES.
- Nurturing young talented researchers to play leadership roles in SIMES. Fisher, Devereaux, Melosh were named as team leaders.

OPPORTUNITIES FOR IMPROVEMENT

- Capital equipment investment to build up scientific infrastructure.
- Need more aggressive effort to build up x-ray materials scattering area – a field where we should be stronger.
- Focused recruitment is needed.

Objective 1.3 Provide and sustain Science and Technology Outputs that Advance Program Objectives and Goals

The research output at SIMES is very significant when weighed against its level of funding. The older programs have a record of sustained productivity, while the newer programs are also very active in terms of scientific publications and the number of talented young people who are being trained.

NOTEWORTHY PRACTICES

SIMES has played an active role in persistently pushing the frontier of x-ray and photoemission spectroscopy for a long period of time. This “well-oiled” scientific capability has enabled ongoing high productivity for its programs.

OPPORTUNITIES FOR IMPROVEMENT

We need new beam line investments at SSRL to allow SIMES’ programs to maintain momentum and space/infrastructure to make research more efficient and to facilitate collaboration. Although we have submitted several proposals, we have not yet been successful.

Objective 1.4 Provide for Effective Delivery of Science and Technology

SIMES disseminates its research findings in scientific journals, conferences, colloquiums and seminars. It also explains its scientific vision and focus through its website.

Noteworthy Practices

- Set up new website[12]
- Media coverage associated with its high profile publications

HEP

E ➤ Accelerator Research

Objective 1.1 Science and Technology Results Provide Meaningful Impact on the Field

Accelerator research at SLAC is pursued by the departments in the Accelerator Research Division (ARD). These include Advanced Accelerator R&D (AARD), Advanced Computations (ACD), Advanced Microwave Technology Research (ATR), Beam Physics (ABP), Linear Collider (LC), LHC Accelerator Research (LHC-AR) and Test Facilities (TF). The LC is described in a separate section. The rest of the effort is covered here.

AARD – Laser Acceleration

The development of a new class of electro-optic devices to use laser light to accelerate electrons is unique in the world and has led to world-leading demonstrations of two new acceleration mechanisms and high-sensitivity high-precision techniques for diagnosing micron- and femtosecond class beams. Collaboration is interdisciplinary and the members are leaders in their respective fields.

Construction of the experimental apparatus for conducting laser driven acceleration experiments was completed and the new beam line and experiment were successfully commissioned and used in scientific experiments.

The E-163 collaboration demonstrated attosecond bunch train formation and the staging of two laser-driven accelerators using techniques that are scalable to a high energy collider.

AARD – Plasma Wakefield Acceleration

The E-167 collaboration on beam-plasma physics concluded with the decommissioning of the SLAC Final Focus Test Beam (FFTB) facility in April 2006. The results of the final round of experiments were published in the journal *Nature* in 2007 and demonstrated a world record combination of accelerating gradient (50 GeV/m) and energy gain (43 GeV) for plasma accelerators.

In 2008 the collaboration proposed the Facilities for Accelerator science and Experimental Test Beams (FACET) project to meet the DOE mission need statement for an Advanced Plasma Acceleration Facility. FACET will be an experimental facility that provides short, intense pulses of electrons and positrons to excite plasma wakefields and study a variety of critical issues associated with plasma acceleration.

SLAC is the only place in the world with the high peak current, high energy electron and positron beams required to continue the development of beam driven plasma wakefield acceleration. With FACET, the SLAC linac will support a unique program concentrating on second-generation research on plasma wakefield acceleration. This program will achieve several key steps on the roadmap to a plasma wakefield based linear collider and will assure continued U.S. leadership in accelerator physics.

ACD

ACD develops and applies high-performance computational tools for the design, optimization and analysis of existing and future accelerator projects in Office of High Energy Physics (OHEP), BES and Nuclear Physics within the DOE. Under the support of the Scientific Discovery through Advanced Computing (SciDAC) computation initiative, these codes solve the most challenging

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computational problems facing accelerator designers and builders using the most powerful computers in the DOE SC. Essential to the ACD program is a strong collaboration with the SciDAC Centers for Enabling Technologies and Institutes that deploy state-of-the-art applied mathematics and computer science techniques to advance ACD's application codes. The modeling and simulation capabilities developed in the past year have had a tremendous impact on accelerators across the DOE complex.

Under the support of the SciDAC Community Petascale Project for Accelerator Science and Simulation (ComPASS), ACD has been continuing to develop high-performance electromagnetic and beam dynamics modeling tools for accelerator design, optimization and analysis. These modeling tools are in production mode on DOE flagship supercomputers at the National Energy Research Scientific Computing Center (NERSC) of LBNL and National Center for Computational Sciences (NCCS) of ORNL and have had significant impacts on applications of numerous important accelerator projects.

- **LHC Accelerator Research Program (LARP) –** Optimization of cell shape and design of power and damping couplers for the crab cavity upgrade; beam heating calculation of a rotatable collimator for the Phase II collimation upgrade; beam-beam simulation for electron lens
- **Linear Collider (LC)** – Beam heating calculation in the main linac cryomodule; multipacting simulation for the TTF-III coupler; validation of crab cavity design with measurements
- **High Gradient Structures** – Design of a choke coupler; optimization of high-order mode (HOM) damping of a choke structure; wakefield and HOM damping calculations for the CERN linear collider (CLIC) particle extraction and transfer (PETS) project
- **Muon Collider** – Multipacting simulation for the muon cooling cavity
- **Laser Acceleration** – Power coupler design for optical fibers

ATR

With extensive development of testing facilities and experimental techniques, ATR was able to create a set of empirical laws to design accelerator structures with gradients that exceeded 100 MV/m. The following are some of the recent results of this ongoing effort.

Standing-Wave Accelerator Structures

With the understanding of the scaling laws of these structures, we tested structures that have loaded gradients well above 140 MV/m. This is indeed the beginning of a new era of high gradient accelerator structure designs when compared to the SLAC linac that runs at 17 MV/m.

Traveling-Wave Accelerator Structures

A new accelerator structures design, based on our newly discovered scaling laws for high gradient operations of structures and has been proposed. The design details were carried out at CERN and verified, including the coupler design, at SLAC. The cells were built at KEK. The structure integration, including cell and coupler bonding, was done at SLAC. The structure was tested at SLAC. This ultra-high-gradient accelerator structure was capable of sustaining unloaded gradients above 100 MV/m. The gradient along the structure rises very rapidly from the beginning to the end; the gradient at the output is 1.5 times higher than the gradient at the beginning of the structure. Although this is counter intuitive, the scaling laws indicated that this design would indeed sustain ultra-high gradients.

ABP

The Beam Physics Department has made significant contributions to the accelerator community in the past year:

- Continued and directed a feasibility study on "PEP-X Light Source at SLAC," with the goal of ring optimization aimed at achieving a record minimal beam emittance.
- Made major progress in developing new methods for impedance calculation, theory of beam instabilities and spin dynamics. The results of these studies are documented in nine publications in peer-reviewed journals.

- Continued educational activities and taught three courses on accelerator theory and beam physics in the USPAS.

LHC-AR

A new LHC Accelerator R&D Department was formed in FY08. Research activities include:

- Phase II collimator development
- Simulations in support of wire compensation and electron lens solutions to emittance growth due to the beam-beam interaction
- Crystal collimation experimentation both at the Tevatron (T-980) and the Super Proton Synchrotron (SPS) (UA9)
- Design of crab cavities for use in large crossing angle schemes for LHC luminosity enhancement
- Modeling and commissioning of the LHC low level RF system
- Studies of vacuum chamber geometry and transverse feedback to suppress electron cloud induced instability in the SPS
- LHC instrumentation commissioning

The first LARP Phase II rotatable collimator jaw was fabricated, a process involving precision machining and state-of-the-art brazing. Metrology measurements showed 25 micron precision. Thermal mechanical deformation was studied using 10 kW resistive heaters to simulate beam energy deposition and a system of capacitive monitors to measure deformation. Results attained were within 10% of those predicted by finite element model calculations (ANSYS).

A collimator support shaft comprised of molybdenum and copper was designed and fabricated after extensive testing and failed prototypes. The low mass and rigidity greatly improve the mechanical precision of the collimator jaws.

A complete RF shield to electrically connect the collimator jaw to its vacuum tank was designed. These parts have very low contact resistance and do not cause trapped higher order modes. which would result in material heating yet allow the jaw to rotate when required. The design has been validated with bench testing, calculation and computer modeling.

Next Linear Collider Test Accelerator (NLCTA)

R&D conducted at the NLCTA leads the world in (1) high-gradient RF (HGRF) technology at X-band and (2) laser-driven structure-based acceleration. Work directly supports DOE's accelerator-based high energy physics mission by developing techniques to be used to build future accelerators.

Techniques and apparatus for high-power RF device conditioning and characterization are sought out by users the world over. Novel approaches to acceleration with microwave and laser radiation are being pursued, leading to new RF pulse power components and new optical devices. Selection of 12 GHz technology by CERN for CLIC provides strong evidence that the long-term investment in high-frequency RF technology will pay off.

Collaborators from CERN and Russia come to the NLCTA to use its unique facilities. In particular, CLIC accelerator structures tested in the past year have achieved their goal of stable operation at gradients above 100 MV/m. Staff members are leaders in their fields. X-band structures from collaborators have been successfully tested and characterized. Preparatory work for RF switch testing is complete.

Both the microwave and laser-driven acceleration programs have achieved their respective performance goals.

NOTEWORTHY PRACTICES

Beam Physics

A new approach to impedance calculations, a so called optical approximation, was developed and applied to various 3D beam pipe transitions that one encounters in vacuum chambers of accelerators. The method is applicable to high frequencies and transitions that are short compared to the catch-up distance. The worked out examples include:

- An iris/short collimator in a beam pipe
- A step-in transition
- A step-out transition
- More complicated transitions

The method was applied to the ILC superconducting RF cavities for calculations of the kick factor due to the presence of nonsymmetric cavity couplers. The obtained results agree reasonably well with numerical calculations.

ACD

INCITE Award "Petascale Computing for Terascale Particle Accelerator: International Linear Collider Design and Modeling"

Proposed by ACD, it is one of the 55 projects awarded by SC, with a total of 265 million hours of computing time on some of the world's most powerful supercomputers as part of its 2008 Innovative and Novel Computational Impact on Theory and Experiment (INCITE) program.

Beam breakup in TJNAF CEBAF 12-GeV Upgrade

Beam breakup (BBU) was observed at well below the designed beam current. HOMs, with an exceptionally high quality factor (Q), was measured and the cause was attributed to cavity deformation during the fabrication process. Using shape uncertainty quantification tools developed under SciDAC, the cavity was found to be 8 mm shorter than designed, which was subsequently confirmed by measurements. The result explains why the troublesome modes have high Qs because in the deformed cavity, the fields are shifted away from the HOM coupler where they can be damped. This greatly underscores the importance of quality control in cavity fabrication. It also points to the success of the SciDAC multi-disciplinary approach to solve an important problem for DOE through a joint effort in accelerator modeling and applied mathematics.

ATR – Collider-Ready Structures

Entered into a work-for-others agreement to design and build a frequency scaled version of our XL-4 klystron for CERN's CLIC program. Similar agreements with the Paul Sherrer Institut (PSI) and Trieste labs are pending. We are in discussion with LLNL scientists to produce x-band linac components and RF sources for a Compton x-ray source.

OPPORTUNITIES FOR IMPROVEMENT

AARD – Plasma Wakefield Acceleration

An extensive experimental, design and simulation effort must be continued to answer the many remaining questions about the eventual applicability of the plasma-based wakefield acceleration to future accelerators and colliders. We must win approval for the FACET proposal continue the program and collaboration.

ATR – Materials

The work on materials is guided by our newly developed theoretical and simulation models for the RF breakdown phenomenon. The models are not simple and will not be described here, but they point to copper alloys, such as copper chromium and copper zirconium, as having the potential for achieving ultra-high-gradients. An active experimental program is exploring these materials and the program will benefit from strong national and international participation.

ATR – Collider-Ready Structures

With the recent developments, it is very clear that one can make accelerator structures with gradients exceeding 100 MV/m. However, the high gradient structures tested to date lack very important features:

1. Wakefield damping

2. Efficient fundamental mode couplers
3. Integration of short structures into super structures

This is true for both the traveling and standing-wave accelerator structures. Research into these topics is intensifying theoretically and experimentally. We are currently developing ideas, simulations and designs for both traveling and standing-wave accelerator structures. The efforts are global and we are trying to optimize the work load internationally.

LHC-Accelerator Research

Fabrication of a two jaw collimator with integrated rotation and step drive in a vacuum system will occur in FY09. Procedures to allow lower cost fabrication of multiple units will be developed.

Objective 1.2 Leadership in Science and Technology

Members of the SLAC Accelerator Research Division serve on a large number of committees and reviews. Members of AARD were on the Advanced Accelerator Concepts (AAC) Workshop Organizing Committee and Working Group Leader, the A0 Photoinjector and PAC Program Advisory Committees, the Director's Review of LBNL in 2008, the DOE-HEP Accelerator R&D Program Review and the Brookhaven National Laboratory (BNL) HEP Program Review. Members of ABP serve on the IHEP BEPC-II IMAC, CSNS MAC and NSRRC steering committee, KEK B-Factory MAC, Spallation Neutron Source (ANS) Accelerator Systems Advisory Committee, BNL C-AD Advisory Committee, USPAS Governing Board, USPAS Program Committee, Overseas Chinese Physics Association (OCPA) Accelerator School Organizing Committee and the OCPA Council. Members of ATR were on the program committees for Linac08, CLIC08, PAC09 and the 2nd International Workshop on High Gradient Accelerator Structures, held at KEK.

SLAC is the host of the U.S. high gradient research collaboration for future colliders. Tantawi is the spokesman for this collaboration and Ruth is a member of the advisory council. Tantawi and Ruth are members of the advisory board for the CLIC Test Facility (CTF3) experiment at CERN. Raubenheimer is chair of the CLIC Accelerator Advisory Committee.

The SLAC LHC-AR group is led by Markiewicz, who is the LARP level 1 Accelerator Systems leader and Deputy LARP program manager. He is also a level 2 Collimation leader and level 3 Rotatable collimator leader and a member of the U.S./CERN LARP committee. For ILC, he is a member of the Machine Detector Interface Committee and the American Linear Collider Physics Group Machine Detector Interface and Backgrounds Coordinator. For the silicon detector (SiD) collaboration, he is an Advisory Board member, Machine-Detector Interface Liaison and a member of the Engineering Group.

Members of ABP and ATR taught four classes at USPAS. ABP also has the editor of Journal Reviews of Accelerator Science and Technology, Handbook of Accelerator Physics and Engineering, Springer Verlag and the Particle Acceleration and Detection Series. ARD members also referee papers for Physics Review Letters, Physical Review Special Topics – Accelerators and Beams (PBST-AB) and other journals and review National Science Foundation (NSF) proposals and Small Business Innovation Research (SBIR) applications.

Parallel Finite-Element Electromagnetic Modeling

ACD maintained its leadership in high-performance electromagnetic modeling in accelerator through continuous improvement of existing codes and development of new application software. The new 3D parallel finite-element particle-in-cell code Pic3P, the first of its kind in the academic community, was used to model the LCLS RF gun including realistic 3D initial particle distribution with extraordinary computational accuracy and efficiency. Domestic (e.g. BNL) and foreign (e.g. PSI, Switzerland) collaborations were formed to apply Pic3P to their designs. The TEM3P code incorporated electromagnetic, thermal and structural effects provided the community with the first parallel multi-physics tool for accelerator prototyping.

Collaborative Research in Computer Science and Applied Mathematics

Under SciDAC ComPASS, ACD assumed a leading role in collaboration with SciDAC Centers for

Enabling Technologies (CETs) or Institutes to develop and deploy advanced computational techniques and novel numerical algorithms to ACD accelerator modeling tools, which provided meaningful impact on accelerator simulation. The collaborations with SciDAC CETs contributed to the success in the following research areas.

- *Shape uncertainty quantification tool* (with Towards Optimal Petascale Simulations or TOPS) – Using measured cavity parameters as input, a deformed cavity is recovered by solving an inverse problem through an optimization method. It was used successfully to determine the cause of the BBU in the CEBAF 12-GeV upgrade.
- *Scalable linear solver for large systems* (with TOPS) – Scalable linear solvers based on per-node memory usage on the latest DOE supercomputers were developed to solve large accelerator systems. This enabled the eigensolver Omega3P to carry out the first-ever calculation of HOMs in the ILC cryomodule which consists of eight superconducting cavities chained together.
- *Adaptive mesh refinement* (with ITAPS/RPI) – A refined adaptive mesh window moving along with an electron beam was implemented in the time-domain code T3P that can reduce wakefield computation time by an order of magnitude.
- *Dynamic load balancing* (with Combinatorial Scientific Computing and Petascale Simulations [CSCAPES]) – The partitioning tool Zoltan developed at Sandia National Laboratory was used in Pic3P for efficient load balancing of the particle computation effort so that Pic3P parallel performance scaled to thousands of CPUs.

Objective 1.3 Provide and sustain Science and Technology Outputs that Advance Program Objectives and Goals

AARD – Laser Acceleration

SLAC work on laser acceleration was featured in three invited talks and 17 papers (three refereed).

AARD – Plasma Wakefield Acceleration

The E-167 and FACET collaboration have strong publication and conference presentation histories with substantial educational components (one PhD completed in 2007, two more in progress). They had four invited talks, 20 conference papers and five refereed publications.

ACD

Most of ACD scientific results are published in conference proceedings, with a total of 16 published papers, including a peer-reviewed paper published in the Journal of Computational Physics. ACD staff gave 7 invited talks at various conferences and meetings.

Ph.D. Thesis

In May 2008, a Stanford graduate student, supervised by ACD staff, successfully defended his thesis, "*Parallel hp-adaptive mesh refinement for electromagnetic field solvers using three dimensional vector finite element methods and its application to accelerator structures.*"

ATR

- ATR members published 34 papers in FY08, two in refereed journals.
- KMD developed CERN T-18 and T-26 structures.
- KMD rebuilt the X-band waveguide system for ASTA to allow a wider range of peak power vs. pulse length in support of the ATR high gradient test program.

ABP

Member of the Beam Physics group published 23 conference papers and three papers in refereed journals. The following papers present research highlights in FY08.

- *Optical approximation in the theory of geometric impedance*, G. Stupakov, K. Bane and I. Zagorodnov, **Phys. Rev. ST Accel. Beams 10**, 054401 (2007).
- *Impedance Calculations of Non-Axisymmetric Transitions Using the Optical Approximation*, K. Bane, G. Stupakov and I. Zagorodnov, **Phys. Rev. ST Accel. Beams 10**, 074401 (2007).

LHC-AR

- LHC-AR members gave invited talks at Beams07 and published 5 papers in FY08.
- KMD developed prototype LARP structures.

NLCTA

- Work conducted at the NLCTA was featured in 4 invited talks and 21 papers (three refereed).
- The KMD built one XL-4 klystron to support NLCTA and/or x-band source development.

Objective 1.4 Provide for Effective Delivery of Science and Technology

The SLAC accelerator research program receives consistently strong reviews from the SLAC DOE HEP Program Review, the SLAC Scientific Policy Committee (SPC) and the EPAC.

ARD attracts world class researchers and students while providing forefront work in the advanced accelerator field, in support of the LHC-AR program and in designing new facilities.

ARD's eminence is recognized by invited talks at PAC, EPAC, American Physical Society, AAC and other conferences.

Sustaining a very ambitious test program in support of the High Gradient Research Program under the direction of Dr. Sami Tantawi, four test stands in the KMD provide X-band RF power to support these experiments.

We have experienced delays in designing and fabricating the LSBK (L-band sheet beam klystron) diode due to design complexity creep, underestimation of the scope and a reduction of workforce.

Collaboration with Other Laboratories

Upon the request from TJNAF on investigating the BBU problem encountered in the CEBAF 12-GeV upgrade, ACD scientists delivered the results in a timely manner for the upgrade project review. ACD analysis helped convince the reviewers that there were no remaining issues with the CEBAF cavities. The project was recommended to go into the CD-3 phase.

User Support

ACD codes were installed in many DOE laboratories and research institutions. To facilitate scientists using the codes, ACD organized training tutorials on a regular basis. In April 2008, scientists from BNL visited SLAC to learn the eigensolver Omega3P and the particle tracking code Track3P. These codes have become their major tools for cavity design and analysis since then.

F ➤ Astrophysics

Objective 1.1 Science and Technology Results Provide Meaningful Impact on the Field

One of the best measures of the impact of the astrophysics program on the field is the number of scientific papers published. In calendar year 2007, there were 179 papers published that included members of the SLAC astrophysics program in the authorship. (A publication list is available upon request.) This is an underestimate of the number of papers over the FY08, which will be available in January. Another metric that can reflect upon the success and standing of the program is the list of awards and honors given to members of the program. These include the award of Stanford tenure to Tom Abel and Steve Allen, the award of the American Astronomical Society Rossi Prize to Steve Allen, Risa Wechsler became a Hellman Faculty Scholar, the entire GLAST-LAT team was given a NASA Group Achievement Award, Stefan Funk was given a Mel Schwartz award. Tom Abel became a Terman Fellow and a Distinguished Visiting Professor at McMaster University, Roger Blandford was a James Lecturer at Purdue University, a Sarojini Damodaran International Fellowship at Tata Institute of Fundamental Research and selected to lead the NRC Decadal Survey in Astronomy and Astrophysics.

Scientific Research Highlights

- The first paper from Fermi Gamma-Ray Space Telescope (Fermi), to which members of the program contributed, has just been accepted by *Science* and will appear in print just four months after launch. This paper contains an important new result that probably clears up a major mystery left over by Energetic Gamma Ray Experiment Telescope (EGRET), the previous gamma ray satellite.

- Discovery of TeV emission from a new X-ray binary source suggesting, that more of the unidentified Galactic sources could belong to this category.
- The discovery of a second cluster, like the bullet cluster, which demonstrates that dark matter is collisionless, consistent with it comprising fundamental supersymmetric particles
- An improved understanding of how galaxies and clusters of galaxies were assembled from smaller units and how their observed light distribution relates to the underlying dark matter.
- First implementation of a global adaptive mesh refinement MHD code applied to the evolution of a disk galaxy helping analyze how cosmic rays are transported in a galaxy like ours and, indirectly how the background against which a putative dark matter annihilation signal will have to be detected.
- A new model describing how TeV energy cosmic rays are accelerated at supernova remnants.
- New measurements of microwave background radiation polarization using the BICEP and QUaD telescopes that are being used to constrain physical conditions at the epoch of cosmic inflation.

Technological Developments

- Advances in the Large Synoptic Survey Telescope (LSST) camera design and successful casting of the primary-tertiary mirror and advances in designing the 100PB database
- Re-design of the SuperNova Acceleration Probe (SNAP) electronics and star guider/image sensor, presumably relevant to the Joint Dark Energy Mission (JDEM) design effort currently underway.

NOTEWORTHY PRACTICES

There has been an improvement in the communication of research results internally through the KIPAC teas, the GLAST/Fermi lunchtime talks, the instrumentation seminar series and the ACKS seminar series. There has also been an improved archiving of the papers written within the program. A notable feature of the research is the prominence of postdoctoral fellows and graduate students.

OPPORTUNITIES FOR IMPROVEMENT

The launch of Fermi provides a golden opportunity to write more and better papers over the coming year.

Objective 1.2 Leadership in Science and Technology

The astrophysics program has provided leadership through its role in Fermi, heading the planning for the LSST camera and the SNAP electronics.

The Fermi observatory is a joint NASA-DOE program which was launched on June 11, 2008. Fermi GST has a nominal mission of 5 years, with a goal of 10 years of on-orbit operation. The Large Area Telescope (LAT) instrument is the major instrument on Fermi. The LAT Instrument Science Operations Center (ISOC), based at SLAC and led by Rob Cameron, supports the operation of the LAT instrument in conjunction with the Fermi Mission Operations Center at Goddard Space Flight Center (GSFC) and receives and processes LAT data. The ISOC supports the science program of the LAT Collaboration and produces Level 1 (reconstructed LAT events) and selected Level 2 (science) data to the LAT Collaboration and the science community through the Fermi Science Support Center at GSFC.

The major functions of the ISOC are:

- LAT observation and command-sequence planning and construction
- Monitoring of LAT instrument health and safety
- Maintenance and modification of LAT flight software and the LAT test bed

- Monitoring, verification and optimization of LAT performance
- Receipt and archiving of LAT Level 0 data
- Production and delivery of LAT Level 1 and Level 2 data
- Maintenance and optimization of software that produces and analyses LAT

All of these functions are being delivered.

In addition, members of the LAT science team at SLAC have been providing scientific leadership in multi-wavelength observations, the study of gamma ray bursts, blazars and the search for evidence of dark matter annihilation.

The on-orbit performance of the observatory, the ISOC team and the LAT collaboration has been exemplary. This is a tribute to the decade of careful planning and hard work that preceded launch.

The LSST camera project continues to be led by SLAC and as it has expanded, the management has been enhanced with K. Fouts as overall project manager. SLAC is leading a collaboration of 16 institutions.

The re-design of the SNAP electronics by Haller and his colleagues is a major leadership function.

NOTEWORTHY PRACTICES

Large contributions though the LAT team to the success of Fermi and in the early post-launch operations and continued leadership of the LSST camera effort.

OPPORTUNITIES FOR IMPROVEMENT

Modest reorganization of the ISOC to reflect changing challenges as Fermi proceeds with its science program. Take on more leadership roles in JDEM.

Objective 1.3 Provide and sustain Science and Technology Outputs that Advance Program Objectives and Goals

There have been successful developments of new capabilities in detector development, parallel computing, graphics and electronics that will facilitate achieving program objectives.

NOTEWORTHY PRACTICES

We have provided new routines for analyzing and visualizing observational and simulation data.

OPPORTUNITIES FOR IMPROVEMENT

To use some of this technology to meet educational and public outreach goals.

Objective 1.4 Provide for Effective Delivery of Science and Technology

Integrated, tested and launched LAT to deliver outstanding on-orbit performance of Fermi, as described above.

NOTEWORTHY PRACTICES

The fine performance of Fermi and the speed with which scientific papers have been completed as described above.

OPPORTUNITIES FOR IMPROVEMENT

Contribute more to Fermi-LAT science output. Write more and better papers that advance other science goals.

G ➤ B-Factory

Objective 1.1 Science and Technology Results Provide Meaningful Impact on the Field

BABAR

BABAR is a large international collaboration of more than 500 physicists, comprising about 150 ongoing PhD and 80 young researchers in postdoctoral positions. It is managed centrally at SLAC and reports twice a year to an International Finance Committee (IFC), which always provided unflinching support throughout the years, most notably in time of need. This strong international support combined with the vitality of the collaboration has made it a model of success, with a very high science output.

The primary goal of the *BABAR* experiment is to investigate the origin of the breaking of charge parity (CP) symmetry in interactions between elementary constituents of matter, a phenomenon that relates to the origin of the imbalance of matter and antimatter in the universe. Understanding this phenomenon is among the key elements of the science mission of the DOE. Towards this goal, the experiment has made enormous strides since the start of its operation in 1999, while taking data on the Υ(4S) resonance. The main goal of the experiment was to validate, or infirm, the Cabibbo-Kobayashi-Maskawa (CKM) mechanism, which is able to explain CP violation within the Standard Model, but which is unable to explain the known matter-antimatter asymmetry of the universe. The experiment established very quickly the first evidence for the breaking of the CP symmetry in decays of B mesons. The results from *BABAR*, together with those from the Belle experiment at Japan's *B*-Factory, have now established that the Standard Model is the main source of observed CP violation effect in the quark sector, thereby paving the way for the Nobel Prize consecration of Kobayashi and Maskawa in October, 2008. The implication of the validity of the CKM paradigm is that new CP breaking effects beyond the Standard Model are needed to explain the matter-antimatter asymmetry in nature. Continuing to collect more data on the Υ(4S), with an upgraded detector, was the initial goal of the experiment for FY08. The aim was to perform precision measurements on a range of processes that are sensitive to the effects of new physics and may shed light on this fundamental question in science and more generally to improve the numerous studies that are statistically limited.

However, the severe FY08 funding issues lead to a drastic revision of this program. At the very end of 2007, it became clear that the data taking on the Υ(4S), initially granted and well prepared for by an extended upgrade effort of both the collider and the detector, was not going to take place. Then, the *BABAR* management, in close coordination with all the international partners of the collaboration, put forward a completely revised program, taking stock of the curtailed data taking imposed in 2008. The new proposal, namely running on the Υ(3S) and Υ(2S) resonances, received strong support from the DOE. It implied trading an insignificant statistical increase on the Υ(4S) data into a statistically very significant data taking on these poorly known resonances. This revision of the program had complex implications on both PEP-II and *BABAR* data taking operating modes. The numerous and necessary changes were put into place in a scramble within the last days of 2007. The success of this immediate reconfiguration demonstrates, once more, the vitality of the PEP-II team and of the international *BABAR* community. The success of this daring gamble is strikingly illustrated by the fast discovery by the *BABAR* collaboration of the long awaited b-meson ground state, which eluded searches for 30 years: the η_b(1S). This discovery, which was the result of the analysis work of a team of a few SLAC physicists, was press-released on the of July 9, immediately approved for publication and actually published on the of August 15; which sets the record for our fastest published analysis.

The data-taking period of the experiment ended on the April 7, 2008. The final *BABAR* data sample comprises: 432.9/fb at the Υ(4S); 30.2/fb at the Υ(3S); 14.5/fb at the Υ(2S); and 53.9/fb of data taken outside the above resonances, including 5/fb of a dedicated scan above the Υ(4S), through the Υ(5S) up to the Υ(6S) regions.

As a result of the above, the *BABAR* B physics program encompasses four main goals: (1) study of CP violation in B meson decays and tests of the CKM paradigm through measurement of a complete set of CP-violating asymmetries and CP conserving observables in *B* meson decays; (2) search for the effects of physics beyond the Standard Model, through a systematic exploration of rare decay processes; (3) detailed studies to elucidate the dynamics of processes involving heavy quarks, including, with the data taken in FY08, detailed studies of the whole b-meson system and search for new physics in the new windows opened in this sector; (4) systematic use of initial state radiation (ISR) data to study the whole energy domain below the Υ(nS) resonances.

The first two goals focus on testing the Standard Model, measuring its parameters and searching for the effects of new physics. The third goal is designed to build a solid experimental foundation on two subjects. On one hand, it aims to elucidate the interplay between electroweak and strong interactions in heavy-quark processes. On the other hand, it aims to discover the missing pieces of the bottomonium spectrum, as well as to probe for new physics phenomena like the production of light Higgs or dark matter candidates. The fourth goal allows, for example, to pin down lower energy e+e- hadronic annihilation, which has far-reaching implications. The physics reach of the experiment is, however, much broader and includes a wide range of topics in charmed hadron's physics, tau lepton decays and strong interaction effects. These measurements have thus far yielded major new findings, including the first observation of particle antiparticle oscillation in the charmed system (D^0 mixing), the observation of new charmed mesons states and observation of new resonances that point to the existence of exotic states of Quantum Chromo-Dynamics (QCD).

The *BABAR* experiment continues to be a powerful science engine providing physics results with unique impact in the field of elementary particle physics. The scientific productivity and impact of the experiment in FY08 is as follows: 61 articles submitted to refereed journals and 136 invited talks by *BABAR* collaborators. In FY07, the collaboration identified a set of about 100 so-called "Core-Analyses" which are analyses meant to be published before the end of 2010. Among these, 21 were already submitted or published this year, half of them likely to be the final *BABAR* results.

A few highlights illustrating some of the *BABAR* most important physics results obtained in FY08 are presented below.

Discovery of the η_b, the Bottomonium Ground State

The first observation of a b-meson, made in 1977, was rapidly followed in later years (1982, 1985) by the reconstruction of a fraction of the spectroscopy of the b anti-b bound states. Whereas the measurement of the complete spectrum of the bottomonium system would provide critical input to check lattice QCD predictions, a significant fraction of the spectrum still eludes observation. In particular, although searched for since many years, the bottomonium ground state, the so-called ηb(1S), was a strikingly missing part, as more generally, all of the spin-singlet states ηb(1S), ηb (2S), ηb (3S), hb(1P) and hb (2P). The first analysis based on the FY08 data taking was a (blind) analysis, completed early July, which lead to the 10σ discovery of the ηb (1S), from the decay Y(3S) → γ ηb (1S).

D^0 Mixing

One of the most important finding by *BABAR* last year was the first observation of D0 mixing, a long sought after process which is highly sensitive to effects of physics beyond the Standard Model. This was soon confirmed by the Belle experiment in Japan and was one of the most important physics results of last year. This discovery was strengthened even more in FY08 by two new analyses, each of the publications reporting on a more than 3σ effect.

R Ratio Measurement with ISR

Among the long-standing hints for signal for new physics is the persistent more than 3σ discrepancy between the *g-2* measurement made at BNL (a half per million precision measurement) and the Standard Model prediction. A key component of the latter prediction comes from e^+e^- data and τ data, which are used to infer the hadronic contribution to the *g-2* prediction through dispersion integral. The bulk of this hadronic contribution (and the bulk of its uncertainty) stems from the low invariant mass region of the ρ resonance, where e^+e^- and τ data significantly disagree. To tackle this critical issue, several years ago the *BABAR* Collaboration launched an ambitious analysis program aiming at the measurement of the R ratio based on ISR events, with the goal to achieve a measurement at better than the percent level. In September 2008, preliminary results were presented for the critical ρ region. The *BABAR* results are in better agreement with τ results (most notably with the Belle analysis) and will lead to a significant reduction of the disagreement between the BNL measurement and the Standard Model prediction (below 2σ).

Tests of the CKM Paradigm

From the outset, a major goal of the *BABAR* experiment has been to perform tests of the CKM paradigm by over-constraining the CKM unitarity triangle. This requires a complete set of measurements of the three angles α, β and γ, and the sides of the unitarity triangle. With the increasing size of the available data sample, the determination of the angles α and γ, both of which requires measurements of the rates and CP asymmetries in a large set of rare processes, became possible. *BABAR* continues to extract more information from its data that pertain to this principle goal of the program. Among the key measurements performed in FY08, several use our full data set on the Y(4S). These are:

- For β, the final analyses of the so-called golden modes and the final analysis of the channel $B \rightarrow \psi\pi^0$, the latter showing evidence at 4σ level for a purely Standard Model CP violation
- For α, the preliminary analyses of the two-pion final states and the publication of the analysis of the $\rho\rho$ final state, including the first use of the $\rho^0\rho^0$ time distribution.

Concerning the latter, as a means to underline the achievements of the *BABAR* Collaboration, it is worth noting that the Belle Collaboration, with a data sample 40% larger, only sets an upper limit for the branching ratio $B \rightarrow \rho^0\rho^0$. For γ we also published an improved analysis based on the most powerful method for the extraction of this angle, which relies on the $B^+ \rightarrow D^{(*)}K^{(*)+}$ channel: leading to a (statistically limited) 3σ evidence for CP violation.

Search for the Effects of Physics Beyond the Standard Model

A key element of the *BABAR* physics program is searching for the effects of new physics either through loop-dominated rare decays of B mesons or, thanks to data taken in FY08, through decays of Y(nS) resonances. Only a few selected examples are given here, for the sake of illustration.

A relatively clean set of observables sensitive to the effects of new physics are time-dependent CP violating parameters in the so-called $b \rightarrow s\bar{s}s$ penguin diagrams containing virtual quarks and vector bosons. Because of the loops involved, such modes are sensitive to new physics at high mass scales beyond those directly produced by present day experiments. *BABAR* has performed a comprehensive set of measurements of CP asymmetries in these channels. In FY08, *BABAR* updated almost all the time dependent analyses with the full data set. The overall picture is that the previous indications of discrepancy with the Standard Model predictions, which were hinting for clear-cut new physics effects, are now fading away. However, the analyses will remain statistically limited until a possible super *B*-Factory comes into play.

The preliminary results of an analysis of the FY08 data taken at the Y(3S) resonance, searching for a possible Higgs-like light partner (present in NMSSM), ruled out a vast domain of the parameter space of this appealing model.

Early FY08, the Belle collaboration reported a striking observation of a new, charged, charmonium-like resonance denoted Z(4430). At the end of the same year, *BABAR* presented a detailed analysis (which is still preliminary) of a set of decay channels of the putative Z(4430). This detailed analysis does not confirm the existence of this new state, but instead provides a possible standard, but subtle, explanation for the effect observed by the Belle collaboration.

Analysis and Simulation Tools

Since its inception, the *BABAR* collaboration has developed or contributed to develop a variety of analysis and simulation software tools that are in use in high-energy physics and other fields. For example, last year the StatPatternRecognition package for multivariate classification and "data mining", which arose from *BABAR* analysis but is now maintained as open-source software and used outside HEP, was further developed with additional capabilities and was used to provide significant improvements in *BABAR's* particle identification performance. New ideas have been developed within the collaboration this year, which will be implemented in the coming months. *BABAR* members also contributed to the development of a similar package, TMVA, which is now in wide use and which stems directly from the pioneering *BABAR* Cornelius package. The RooFit package for data modeling, which was developed within *BABAR* to address the complex requirements of time-dependent CP fits, also continues to be developed. It is now distributed as part of the ROOT system that is almost universally used in high-energy physics and increasingly adopted in other scientific communities. *BABAR* members also contributed to the validation of new releases of the standard particle-interaction simulation toolkit, GEANT4, widely used in HEP, nuclear physics, medical imaging and beyond. A *BABAR* collaborator is also a member of the core GEANT4 development team.

Work on all these packages has been presented at various international conferences and workshops on computing for high-energy physics, data analysis and simulation.

PEP-II

PEP-II is an e+e- collider operating in the Upsilon 4S region. PEP-II was constructed from 1993 to 1998. It had colliding beams from 1998 into 2008 delivering integrated luminosity to the *BABAR* detector. PEP-II had a peak luminosity of 1.2 x 10^34/cm^2/s and held the world's record for several years. PEP-II delivered a total of 57.4/fb in FY08 and 557/fb over its lifetime. PEP-II delivered luminosity on the following Upsilon resonances: 2S, 3S, 4S, 5S and 6S. PEP-II was turned off April 7, 2008, ending a 10 year operational life.

The data delivered by PEP-II to *BABAR* was instrumental in proving the theory leading to two Nobel Prizes awarded in October 2008.

PEP-II has entered a Minimum Maintenance State (MMS). An effort to study PEP-II disassembly and disposal (D&D) has started.

NOTEWORTHY PRACTICES

PEP-II

The uptime efficiency of the PEP-II accelerator complex containing the linac injector and two storage rings over its operational lifetime was about 82%.

OPPORTUNITIES FOR IMPROVEMENT

PEP-II

PEP-II terminated operations April 7, 2008.

Objective 1.2 Leadership in Science and Technology

BABAR

The *BABAR* experiment at SLAC is one of the leading experimental programs in the U.S. and worldwide. Its program is focused on the investigation of the breaking of CP symmetry using the decays of B mesons, where it leads the field together with the Belle experiment at KEK, Japan. The experiment gathers a collaboration of more than 500 physicists from 74 institutions in 10 countries, the U.S., Canada, France, Germany, Italy, Netherlands, Norway, Russia, Spain and UK. In addition to its mission to advance the knowledge of elementary particle physics, the *BABAR* collaboration with a young researcher base of about 150 PhD graduate students and 80 *BABAR* research associates, is one of the leading institutions worldwide in training the high-energy physicists of the future.

Members of the *BABAR* collaboration are very active in serving the physics and high-energy physics community in a variety of capacities. For example, the current chair and chair-elect of the Division of Particles and Fields (DPF) of the American Physical Society are members of the *BABAR* collaboration, as is the President of the Commission for HEP in INFN (Italy) and as were the two previous Deputy Director for HEP in IN2P3 (France). Several current and former members of the *BABAR* collaboration served or are serving as directors of major laboratories, including both SLAC and Fermi National Accelerator Laboratory (FNAL), LAL (Orsay, France), CPPM (Marseille, France) and LAPP (Annecy, France). *BABAR* collaborators also served on numerous national and international panels, including review committees at FNAL, CERN, DOE and the NSF. *BABAR* collaborators are regularly among the principal organizers of several major conferences, each year.

PEP-II

The PEP-II rate of data delivery to *BABAR* was the best in the world in FY08 with 57.4/fb delivered.

NOTEWORTHY PRACTICES

PEP-II

- The PEP-II highest electron beam current is a world's record of 2.069 amperes.
- The PEP-II highest positron beam current is a world's record of 3.213 amperes.
- PEP-II collided a record number of bunches, which is 1732 bunches.

OPPORTUNITIES FOR IMPROVEMENT

PEP-II

Additional upgrades (increases) of the PEP-II luminosity were possible but were not achieved because the turn off date arrived too soon.

Objective 1.3 Provide and sustain Science and Technology Outputs that Advance Program Objectives and Goals

BABAR

As discussed in section 1.1, the *BABAR* experiment continues to produce high quality physics results with significant impact on the advancement of our understanding of elementary particle physics and the scientific direction of the field. Various statistical measures of the scientific productivity and impact of the experiment in FY08 are presented in section 1.1 and expanded below:

- Number of articles submitted to refereed journals: 61
- Number of invited talks by *BABAR* collaborators: 136
- Number of new physics results presented at ICHEP2008: 90 (3 plenary talks)

As of the end of FY08, the total number of submitted (published) *BABAR* papers is 375 (360, for a total number of citations of 11450 and an h-index of 52). The number of publications (and their average citations) in Phy. Rev. Lett. are 161 (42) and the corresponding numbers in Phys. Rev. D. are 176 (21). Since the start of data taking, the *BABAR* collaborators have presented 890 invited talks at major conferences.

One of the major milestones of the DOE for advancement in understanding the phenomenon of CP violation has been the determination of CP asymmetry in the charmonium decay channels, sin2β, to an accuracy of 0.04 or better. The measurements from the *B*-Factory experiments have already passed this milestone and two other angles α and γ have been pinned down, although their measurements remain statistically limited.

PEP-II

The PEP-II staff published about 10 technical papers in scientific conferences in FY08 to document the advances in the performance of PEP-II. These publications have been in strong demand from the designers of other future accelerators including NSLS-II, Super-B and BEPC-II.

NOTEWORTHY PRACTICES

PEP-II

The PEP-II staff has systematically documented technical designs over the lifetime of the project.

OPPORTUNITIES FOR IMPROVEMENT

PEP-II

An "as-built" document should be produced for PEP-II as part of the PEP-II D&D process.

Objective 1.4 Provide for Effective Delivery of Science and Technology

BABAR

Among the key measures of *BABAR* 's effectiveness in the delivery of science are its abilities to efficiently record the data from the PEP-II collisions and to process and make available the data for physics analysis in time for presentations at major conferences and for publications in peer reviewed journals. This is best illustrated by the way the data taken this year, in a new collider and detector environment, were transformed within two months into the discovery of the η_b. In FY07 and through FY08, the collaboration launched a major Monte Carlo simulation and reprocessing of its full data set to implement important event reconstruction improvements. In addition, the collaboration processed the last live data (Run-7) from the detector.

PEP-II

PEP-II delivered 57.4/fb to *BABAR* during FY08. PEP-II luminosity delivery time to *BABAR* was 1902 hours for 68% of the time. PEP-II machine development time was 45 hours for 1.6% of the total time. Injection and tuning was 457 hours for 16.2% of the time. Unscheduled down was 411 hours for 14.6% of the time. Overall, running uptime efficiency was 85.4%.

NOTEWORTHY PRACTICES

PEP-II

PEP-II machine operation was very efficient this year, achieving over 85% uptime and included a move of the beam energy to cover the 5 Upsilon resonances.

OPPORTUNITIES FOR IMPROVEMENT

PEP-II

Beam time operation could be made more efficient by knowing the budget and run schedule in advance.

H ➤ Elementary Particle Physics

Objective 1.1 Science and Technology Results Provide Meaningful Impact on the Field

Theoretical Physics

The work of the SLAC Theoretical Particle Physics group is broadly divided into particle phenomenology and model building and formal quantum field theory and string theory. The group consists of eight faculty members—Stanley Brodsky, Lance Dixon, JoAnne Hewett, Shamit Kachru, Michael Peskin, Helen Quinn, Eva Silverstein and Jacob Wacker—and two staff members—Thomas Rizzo and Marvin Weinstein. The group also supported eight research associates in FY08.

The major activities of the group members are described below.

Brodsky

Exploitation of correspondence between string theory in anti-de Sitter space and conformal field theories in physical space-time including a novel QCD explanation of the remarkable baryon anomaly seen in RHIC heavy ion collisions; a new mechanism for diffractive Higgs production; and detailed study of the effective three-gluon vertex in perturbative QCD.

Dixon

Development of new techniques for efficient and automatable precision calculation in next-to-leading order for QCD production of jets at the LHC using loop-level recursion relations and algebraic methods for determining coefficients for box diagrams; implementation of these methods in the C++ program BlakHat.

Hewett

Production and elucidation of new physics at the LHC and a linear collider, including constraints obtained from the study of rare processes; study of the ability of colliders to disentangle parameters of the supersymmetry Lagrangian in the general 20-parameter CP-conserving MSSM; comprehensive analysis of possible new physics contributions to mixing and constraints derived from recent observation of this process.

Kachru/Silverstein

Construction of string models containing explicit mechanisms for supersymmetry breaking.

Peskin: Study of implications of data from high energy collider for dark matter, including the implications of future LHC and ILC cross section measurements for SUSY model explanations for dark matter and development of simulation tools for LHC physics.

Quinn

Contributions to improved measurement of CKM angles through collaborative studies based on data from *BABAR* at the PEP-II *B*-Factory.

Rizzo

Exploration of phenomenology of the MSSM at colliders, studies of resonances from extended gauge sectors and extra dimensions and exploration of "unconventional" models leading to distinctive signatures, such our ability to extract information about on underlying ADD model parameters from Tev-scale black hole production at the LHC.

Wacker

Model building and effective field theory as tools for developing experimental signatures for new physics, particularly with unusual or difficult experimental signatures, such as gluinos with long-lifetimes from split supersymmetry, Higgs boson decays predominantly to a cascade of four tau leptons and search strategies for color octet particles that decay into jets plus missing energy.

In FY08, the SLAC HEP theory group produced 73 papers. About 45 of these were submitted to refereed journals; of these, 35 have already been accepted for publication. The other articles will appear in conference proceedings and reports. This work includes the important new results summarized below.

In QCD:

- Developed a computer code for automatic generation of one-loop QCD corrections to multiparton amplitudes. This code produced the first one-loop corrections to W and Z plus 3 jet amplitudes and is expected to scale smoothly to higher numbers of jets.
- Developed a new matrix element generator for QCD and applied it to predict cross sections for up to 8-jet events in hadron-hadron collisions.
- Developed an explicit correspondence between light-front hadron wavefunctions and the wavefunctions that appear in gravity duals of QCD. From this, constructed new models of the light-front wavefunctions applicable to QCD exclusive reactions in the phenomenology of new physics models.
- Proposed a new scheme for model-independent analysis of supersymmetry searches and possible signals at hadron colliders. This analysis was applied to the supersymmetry searches at the Tevatron, deriving new and more model-independent constraints.
- Proposed a method to improve the current limit on atom neutrality by seven orders of magnitude, using an atom beam interference technique.
- Carried out a survey of the ability of the ILC to determine the detailed quantum numbers of supersymmetric particles. As a part of this work, new analysis techniques were proposed for the most difficult cases of supersymmetry observation at the ILC.

In model-building for new physics:

- Discovered a gravity dual of the mechanism of supersymmetry breaking in a metastable vacuum state. This dual converts strong-coupling aspects of the scenario to a weak-coupling regime, enabling detailed study of the mechanism.

- Constructed the first model of gauge-mediated supersymmetry breaking with the neutralino heavier than the gravitino, thus making the neutralino the dark matter particle. The model is based on a strong-coupling supersymmetry breaking sector whose properties are computed using the gravity dual.

In cosmology:

- Proposed a string theory of inflation that explicitly realizes the possibility of field expectation values much greater than the Planck scale and predicts a substantial gravity wave signal in the cosmic microwave background.

In general mathematical physics:

- Discovered gravity duals for Lifshitz point quantum phase transitions found in condensed matter systems.
- Demonstrated the explicit cancellation of ultraviolet divergences in N=8 supergravity at the three-loop level, giving further evidence for their proposal that this theory of gravity is finite.

I ➤ ILC Program

Objective 1.1 Science and Technology Results Provide Meaningful Impact on the Field

After publishing the Reference Design Report (RMD) in 2007, the ILC collaboration began a technical design phase. SLAC has several important leadership roles in that effort. E. Paterson is the System Integration Engineer and a member of the global design effort (GDE) Executive Committee. T. Himel and T. Raubenhiemer are members of the ILC Project Advisory Committee and T. Himel is a member of the International Detector Advisory Group. A. Brachmann, C. Adolphsen and A. Seryi are level 3 leaders for the Electron Source, Linac Systems and Beam Delivery Systems. SLAC led the Positron Source and Ring-to-Main-Linac areas for the Reference Design Report (RDR), but transferred leadership in FY08 to the UK and FNAL. SLAC also had major roles in RF power sources, power supplies, controls and installation. With the budget cuts of December 2007, most of these activities were suspended and engineering staff was greatly reduced. Work continued on a few areas with broad applicability to any linear collider or to other potential future projects. These included source laser prototyping, photocathode R&D, electron cloud studies, L-band RF power sources, wakefield simulations and certain beam delivery topics such as crab cavities, dumps, IR layout. SLAC also continues to have a leading role in the accelerator test facility (ATF2) in Japan.

Electron and Positron Sources

Operations resumed in the linear collider gun test laboratory (GTL) after a 3 year shut down. GTL is being used to characterize polarized electron photocathode wafers that are being developed for use in future linear colliders. A few cathodes are characterized at the cathode test lab. Several cathode-related SBIR projects were also finished.

A laser system is being developed to allow testing of candidate photocathode samples at full linear collider operations specifications. This laser system serves as a pre-prototype of a linear collider injector drive laser. Key laser and amplifier components were acquired in FY08.

Damping Rings

During the last two years, researchers at SLAC installed three major experiments in the PEP-II beam line involving special vacuum chambers to study the electron cloud effect. These tests were instrumental in the understanding and suppression of the single-bunch instability driven by a large electron cloud density that may form in existing and future particle accelerators.

The three experimental area included 1) tests to monitoring the important reduction of the surface secondary yield (SEY) of technical vacuum materials, 2) successful tests of special grooved chambers as possible mitigation for the electron cloud build-up and 3) tests in a newly installed 4-magnet chicane with proper chambers and diagnostics. In the latter chicane tests, a new resonance effect was discovered related to the multiplication of electrons at special dipole field values, which was earlier predicted only by simulations. The control of this effect could raise the instability threshold in future damping rings by a factor of about 3.

In the next few years, further experiments on the electron cloud will be conducted by SLAC researchers working with collaborators at KEK, CERN and the Cornell CESR Damping Ring Test Accelerator facility.

Bunch Compressors

Work on the bunch compressors was largely transferred to FNAL in FY08. SLAC completed the design of the dump lines, which was in progress.

Main Linac

The main goal of the RF sources R&D is to lower the cost and improve the performance of RF systems for L-band (1.3 GHz) superconducting accelerators. To this end, a 120 kV, 130 A, 1.6 ms, 5 Hz Marx-style modulator was built that has met power specifications and has survived load arcs. This modulator does not have the heavy, inefficient transformer that is typically used in L-band applications.

To generate high power (10 MW) RF, a sheet-beam klystron is being designed as an alternative to the more expensive multi-beam klystrons. Construction of a klystron gun that will test sheet beam generation (40-1 aspect ratio) is nearly complete.

A system for distributing the klystron power to superconducting cavities has been built that is more versatile and cost effective than the ones used at DESY. It features a variable tap-off waveguide system that allows the power to individual cavities to be adjusted to match their gradient potential. A section of this 8-cavity system was recently sent to FNAL to be used for their first cryomodule. The power from such a distribution system is fed to the cavities via power couplers that need to be compact, vacuum isolated, extremely clean and survive large temperature variations (from 300 K down to 2 K). Various parts of such couplers were high power tested to better understand their RF processing limits. Also, a class 10 clean room is being assembled and an RF processing facility has been set up to assemble and RF process couplers for future FNAL cryomodules.

In addition to RF system components, a 1.3 GHz, 5-cell, standing wave, normal-conducting cavity was tested during the past year. It is a prototype for the ILC position capture accelerator, which cannot be superconducting because of the high radiation levels it would see. The cavity achieved the 15 MV/m gradient goal for 1 ms pulses.

Finally, a prototype superconducting quadrupole for the ILC linac that was borrowed from DESY was fitted with a warm-bore cryostat and its field profile measured to determine how much, if any, the magnetic center moves when the field strength is varied. The few micron changes that were observed are within the ILC specifications for certain beam-based quadrupole alignment techniques.

Beam Delivery System

SLAC developed hardware and instrumentation was delivered to the ATF2 at KEK in Japan. This facility will study new methods of beam focusing. The hardware includes high availability power supplies that were developed at SLAC for application to accelerators requiring high reliability and up-time for users, such as light sources and colliders. It also includes submicron resolution electronics for the cavity beam position monitors, as well as devices for precise control of beam line alignment. SLAC also initiated and developed flight simulator software based on Matlab for the control system that would allow seamless integration of accelerator physics and control system tools. The SLAC team is preparing to take part in the commissioning and accelerator physics studies at the ATF2 facility.

High Availability Hardware

The first prototype Marx modulator was tested to full power and final pulse-flattening circuit is in design. Arc protection was improved so all tests passed successfully. Final interlocks are being installed prior to moving to End Station B (ESB) for full power testing of the new 10 MW klystron. A novel VME FPGA based interlock system was completed, it passed functional tests and is undergoing integrated system tests. Phase 1 EPICS control software was completed.

A complete tested 40-unit high availability DC magnet power supply system was delivered to ATF2 at KEK. Engineers supported system installation and test at KEK. An independent development has tested a successful prototype of a dual-redundant auto-failover controller.

The ATCA-VME Adapter design was completed and fabrication is starting. An ATCA for Physics Profile document was completed and a workshop organized in October 2008 to promote international standards collaboration.

End Station A (ESA)

These experiments were executed together in a common experimental setup in ESA and completed data taking in summer 2007, using the 28.5 GeV PEP beam. Analysis and publications took place in FY08.

The experiment titles and collaborating institutions are identified below.

- **T-474/491 BPM Energy Spectrometer**
  Cambridge, DESY, Dubna, Royal Holloway, UC London, UC Berkeley, Notre Dame, SLAC
- **T-475 Synchrotron Stripe Energy Spectrometer**
  U. of Oregon, SLAC
- **T-480 Collimator Wakefields**
  Birmingham U., CCLRC–ASTeC, CERN, Lancaster U., Manchester U., TEMF TU Darmstadt, SLAC
- **T-487 Smith-Purcell Bunch Length Diagnostics**
  Oxford U., Rutherford Appleton Lab, U. of Essex, Dartmouth College, SLAC
- **T-488 Interaction Point BPM Background Studies**
  Oxford U., Daresbury Lab, SLAC
- **Electromagnetic Interference (EMI) Studies**
  U. Oregon, SLAC

The experiments developed prototypes and studied performance issues for:

- Two types of ILC energy spectrometers (T-474/491 and T-475)
- ILC collimators (T-480)
- An ILC bunch length monitor (T-487). The T-488 studied background issues for the interaction region BPMs that keep beams in collision
- The EMI studies explored the electromagnetic background environment near the ESA beam line and the sensitivity of detector EMI.

Objective 1.2 Leadership in Science and Technology

The Linear Collider group at SLAC is the world leader in electron sources, L-band RF power sources and beam delivery systems. It also leads the world-wide program in electron cloud experiments.

The LC group has participated actively in the national and international community through reviews and meetings. SLAC LC members also participated in many advisory and review committees including High Energy Physics Advisory Board (HEPAP), P5, MUTAC, the DPB Executive Committee, the NSF and DOE Committees of Visitors, the LCLS Facilities Advisory Committee, the CLIC and FNAL Accelerator Advisory Committees, the advisory board for the SLAC/FNAL joint SciDAC project (ComPASS) and numerous conference scientific and program committees. LC members have also served as BNL Management Consultant for U.S. ATLAS Detector project (1998-2008), BNL Consultant, NSLS-II Construction Readiness Review (Controls, Magnet Power, Low Level RF), on the Executive Committee, 2008 NSS-MIC & 2009 Real Time IEEE Conferences, as Lead Organizer, invited speaker, 2-day *ATCA for Physics Workshop*, 2008 NSS-MIC, October 2008 and as Standing Chair, IEEE Nuclear & Plasma Sciences Society Conference Policy Committee

(2002-2008).

Two Ph.D. theses are expected in 2008 from the ESA experiments. Christine Clarke successfully completed her PhD in March 2008 from Oxford University on T-488. Victoria Blackmore is expected to complete in fall 2008 from Oxford University on T-487.

Objective 1.3 Provide and sustain Science and Technology Outputs that Advance Program Objectives and Goals

Results from the E166 experiment were published in Physical Review Letters (Vol 100, No. 21, 30 May, 2008). The T-474/491 collaboration published a reviewed paper, *Cavity BPM System Tests for the ILC Spectrometer***,** in NIM-A, Vol 592 (3) July 2008, Pages 201-217.

SLAC work on linear colliders was featured in invited talks at LCWS07, EPAC and AAC and in more than 35 conference papers.

Objective 1.4 Provide for Effective Delivery of Science and Technology

The SLAC Linear Collider program receives consistently strong reviews from the ILC Americas Regional Team Review, SLAC DOE HEP Program Review and the SLAC SPC. The SLAC LC program's eminence is recognized by invited talks at PAC, EPAC, AAC and other conferences.

J ➤ Scientific Computing

Objective 1.1 Science and Technology Results Provide Meaningful Impact on the Field

Scientific Computing and Computing Services (SCCS) has increased its broad impact on scientific computing in the area of large-scale data management. The impact in simulation tools has been maintained. The impact in Grid security and wide-area network performance monitoring has been significantly reduced due to a refocusing of staff on immediately vital mission tasks following the FY08 budget reductions.

NOTEWORTHY PRACTICES

SCCS scientists held the first XLDB (Extremely Large Databases) workshop with strong national/international participation from science, computer science and industry.

OPPORTUNITIES FOR IMPROVEMENT

High-impact activities such as simulation tools must be transitioned from "incidental to the mission" funding to potential new DOE programs targeted at such activities.

Objective 1.2 Leadership in Science and Technology

SLAC leads the key areas of hadronic physics and overall architecture for the GEANT4 simulation toolkit. Key members of the SLAC GEANT4 team were recruited internationally as the acknowledged experts in their fields. SLAC scientists working on the design of responsive petabyte-scale databases continue to lead the design of database systems for the LSST program. Closely allied to this work is a leadership role in bringing science input to steering the new SciDB (open source data management system for data-intensive scientific analytics) initiative to create a revolutionary scientific database to handle petabyte-scale data analysis.

NOTEWORTHY PRACTICES

SciDB focus on achievement through the creation of multi-disciplinary laboratory/university/industry team with well-defined goals.

OPPORTUNITIES FOR IMPROVEMENT

Exploit the *BABAR* computing foundation to bring leadership value to the U.S. LHC program. Use the driver of LCLS science to bring leadership value to the data-intensive frontier in Photon Science.

Objective 1.3 Provide and sustain Science and Technology Outputs that Advance Program Objectives and Goals

SLAC scientific computing continues to be deeply involved in the SLAC science program in addition to advancing scientific computing in areas aligned with the SLAC program.

NOTEWORTHY PRACTICES

In FY08, SLAC scientific computing staff published 10 papers in refereed journals and published conference proceedings, in addition to over 100 papers in which scientific computing members were among the authors of publications from the broader SLAC science program.

OPPORTUNITIES FOR IMPROVEMENT

Ensure that SCCS staff members are encouraged to publish scientific computing advances that will be beneficial to the wider science community.

Objective 1.4 Provide for Effective Delivery of Science and Technology

In SLAC's areas of leadership or major competence in scientific computing, workshops, training and lectures are organized ensure useful delivery of advances to the wider science community.

NOTEWORTHY PRACTICES

The first Extremely Large Databases Workshop was held at SLAC in October 2007 and the second workshop will be held at SLAC in October 2008. GEANT4 user workshops have been organized by SLAC at SLAC and several U.S. locations. Lectures on parallel computing at Stanford have been delivered by SCCS staff.

OPPORTUNITIES FOR IMPROVEMENT

Ensure adequate staff time for these activities.

Goal 2 Efficient and Effective Design, Fabrication, Construction and Operations of Research Facilities

The Contractor provides effective and efficient strategic planning; fabrication, construction and/or operations of Laboratory research facilities; and responsive to the user community.

The weight of this goal is 52%.

The Provide for Efficient and Effective Design, Fabrication, Construction and Operations of Research Facilities goal shall measure the overall effectiveness and performance of the Contractor in planning for and delivering leading-edge research facilities to ensure the required capabilities are present to meet today's and tomorrow's complex challenges. It also measures the Contractor's innovative operational and programmatic means for implementation of systems that ensures the availability, reliability and efficiency of facilities; and the appropriate balance between R&D and user support.

BES/BER (91%)

Element		Letter Grade	Numerical Score	Objective Weight	Weighte d Score	Total Score
2	Provide for Efficient and Effective Design, Fabrication, Construction and Operations of Research Facilities					
2.1	Provide Effective Facility Design(s) as Required to Support Laboratory Programs	B+	3.2	10%	0.3	
2.2	Provide for the Effective and Efficient Construction of Facilities and/or Fabrication of Components	B	3.0	60%	1.8	
2.3	Provide Efficient and Effective Operation of Facilities	A-	3.5	20%	0.7	
2.4	Utilization of Facility to Grow and Support Lab's Research Base and External User Community	B+	3.4	10%	0.3	
					BES/BER Science and Technology Score	3.1
					BES/BER Funding Weight (91%)	**2.8**

HEP (9%)

Element		Letter Grade	Numerical Score	Objective Weight	Weighte d Score	Total Score
2	Provide for Efficient and Effective Design, Fabrication, Construction and Operations of Research Facilities					
2.1	Provide Effective Facility Design(s) as Required to Support Laboratory Programs	B+	3.2	20%	0.7	
2.2	Provide for the Effective and Efficient Construction of Facilities and/or Fabrication of Components	NA	NA	0%	NA	
2.3	Provide Efficient and Effective Operation of Facilities	A-	3.5	80%	2.8	
2.4	Utilization of Facility to Grow and Support Lab's Research Base and External User Community	NA	NA	0%	NA	
					HEP Science and Technology Score	3.5
					HEP Funding Weight (9%)	**0.3**

Total Goal 2 Score: 3.1 (B+)

BES/BER

A ➤ SSRL

Objective 2.1 Provide Effective Facility Design(s) as Required to Support Laboratory Programs

The SPEAR3 beam line upgrade program is being brought to completion with the upgrade and commissioning of BL4, which will be completed in FY09. BL12, a new undulator-based macromolecular crystallography beam line for ultrasmall crystals, funded by the Gordon and Betty Moore Foundation, was commissioned and began user operations. SPEAR3 improvements focused on top-off operation, which included a significant number of tests to confirm the safety of the top-off mode as well as development of radiation monitoring devices and improved injection schemes.

There were a number of projects underway in FY08 that are described below.

Beam Line 7 Upgrade

The overall BL7 upgrade was completed in FY07. In FY08, a number of reliability and stability improvements were made that included upgrade of the BL7-1 monochromator and incorporation of a feedback system to improve the beam pointing stability for BL7-2. Similar to BL6-2, the BL7-2 and BL7-3 liquid nitrogen (LN) cooled monochromators were connected to the house LN distribution system thus reducing the burden on the operations staff and the risk of undesired thermal cycling of the crystal seals.

Beam Line 12 Construction

BL12 commissioning activities were completed and the beam line turned over to regular user operations. Incorporation of a beam-based feedback system had led to improved beam stability and makes possible the study of small protein crystals.

Beam Line 4 Upgrade

The three LN-cooled monochromators and associated slits, masks, filters and stoppers were installed during the fall and winter of FY08. Following extraction of first light from all three branch lines, the optics commissioning followed by some initial commissioning experiments were performed on BL4-2 and BL4-3. Several key milestones were achieved during this period including successful characterization and initial SAXS measurements utilizing LN-cooled, multilayer artificial crystals in the BL4-2 monochromator. Commissioning and performance enhancement activities on all three beam lines will continue in the fall.

Beam Line 13 Construction

The BL13-2 and BL13-3 optics installation was completed by mid-winter and first light extracted using the relocated BL5 EPU. Following a period of optics commissioning activities, these beam lines began initial user commissioning experiments. While these commissioning activities yielded a number of milestones, the BL13-2 vertical focus of 3-4 μm stands out as a notable result. By the end of the FY08, run BL13-2 had transitioned to regularly scheduled user operations. Over the spring and summer the final elements of the BL13-1 branch line for a soft x-ray nano-probe, the M1 mirror and monochromator exit slits, were designed, fabricated and assembled.

Beam Line 14 Construction

BL14 consists of two beam lines, 14-1 for macromolecular crystallography and 14-3 for low energy XAS. The in-alcove hardware is being installed to facilitate installation of the remaining components and subsequent commissioning during the FY09, run while minimizing disruption to the user program. BL14-1, the macromolecular crystallography branch line, is funded by Genentech Inc. and NIH Institute for General Medical Sciences (NIGMS) through the Joint Center for Structural Genomics while BL14-3, the branch line for low energy XAS, is funded by DOE BER and BES.

Enhanced Beam Stability Feedback Systems

The relatively small temperature variations in the SLAC lab-wide low conductivity cooling water have been identified as the source of some mirror optics pointing instabilities. Consequently a local feedback system has been developed to improve the cooling water temperature regulation and has been placed into production on several beam lines. The past year has witnessed the maturation of the gas amplified electron yield beam position monitor developed as a prototype last year for use with the BL12 mirror pointing feedback system. In particular, this detector has been improved for more simplified alignment and better performance over a wide photon energy range. The detector and associated feedback system has been placed into production on six systems.

Building 120 Seismic Upgrade

Funding for the SLAC Safety and Operational Reliability Improvements (SORI) infrastructure project was received in FY07 allowing SSRL to proceed with the planned seismic upgrades of Building 120. This was a complex project that included upgrades to both offices and the experimental floor. As a result, it was divided into two years to minimize disruption to the user program. The project required very close coordination between staff, users and the contractor to maintain a safe working environment and yet allow the contractor to complete the work. As a result, the project was completed in September 2008 within schedule and under budget.

NOTEWORTHY PRACTICES

BL 4 Upgrade

As described last year, the BL4 upgrade was planned in a way to minimize user downtime by rebuilding the beam line in a new location. This plan was successful in reducing the downtime, compared to what it would have been if the beam line had been rebuilt in the original location.

Building 120 Seismic Upgrade

Careful advance planning and good communication between the floor staff, the project manager and the contractor resulted in a safe project that had minimum impact on the productivity of users and staff.

OPPORTUNITIES FOR IMPROVEMENT

Opportunities for improvement in such construction and upgrade projects include detailed planning and constant monitoring of schedules and operational requirements to optimize availability of beam time.

Objective 2.2 Provide for the Effective and Efficient Construction of Facilities and/or Fabrication of Components

The beam line development and upgrade projects described above involved the design and fabrication of sophisticated components to provide the required design performance. SSRL has been able to leverage component designs for mirror and monochromators by utilizing the same designs on multiple beam lines. In the case of accelerator improvements, SSRL effectively collaborates with other laboratories to insure that the best approaches are being utilized. One example of this is the development of top-off operation. In this case, SSRL and ALS worked together to understand the accelerator physics issues, many of which were common to both rings and arrive at common criteria for radiation protection.

NOTEWORTHY PRACTICES

SPEAR3 Top-Off Development

Collaboration with ALS to solve problem associated with top-off in a common way and to be able to review each other’s work.

OPPORTUNITIES FOR IMPROVEMENT

Maintaining Critical Expertise in Beam Line Development

The very challenging DOE budget situation is threatening SSRL's ability to maintain critical expertise in areas related to beam line development. The delay in the ability to fund new initiatives over the past several years has resulted in the need to "lend" engineering staff to other programs. The continued lack of funds for new beam lines will make it impossible for SSRL to focus sufficient staff on critical problems that will ultimately impact the development of PEP-X.

Objective 2.3 Provide Efficient and Effective Operation of Facilities

In 2008, SSRL's operation as a user facility was outstanding, running for a total of 5027 hours. The lower number of hours run in FY08 compared to FY07 is due to the 2.5 week budget-driven shutdown during the spring run. The facility proved to be exceptionally reliable, providing very stable beam for a very high fraction (>97%) of the scheduled time. This uptime, which exceeded expectations, was partially due to the fact that the day-to-day operation was very reliable with short injection times and that there were no major unscheduled downtimes due to equipment failure during the FY08 run. SSRL provided 28 stations on 23 simultaneously operating beam lines. During the FY08 run, scientists on 391 different proposals received beam time in a total of 1,245 experimental starts involving 1,799 users, with approximately 1,147 users on-site or remote accessing beam-line equipment. Approximately 66% of the users came from universities and other laboratories in the United States, 15% from DOE and U.S. government laboratories, 8% from U.S. industry and 11% from international institutions.

At the end of each of their individual runs, users are asked a set of questions to gauge their satisfaction with the performance of the facility. In FY08, the responses for the categories "overall scientific experience" and "beam performance and quality" were approximately 81% excellent and 13% very good indicating a high level of user satisfaction.

Configuration of the Facility to Support the Community

The configuration of the beam lines is regularly reviewed as part of the semiannual proposal review process in which the mix of proposals is examined in light of previous periods. In addition, the oversubscription rate in the beam time request process is also reviewed. Finally, the user end or run summaries are reviewed and disseminated by the user research administrator. These data points serve as guides to SSRL management for determining priorities for beam line support and where scarce resources should be placed.

R&D to Develop and Expand Facility Capabilities

SSRL is continuously developing its capabilities. In particular, a number of accelerator improvements are being carried out that will improve the overall operation and provide for a more stable beam. These developments include: (1) painting the accelerator tunnel roof white to decrease the tunnel temperature fluctuations and improve electron beam stability; (2) installing additional hydrostatic leveling sensors to characterize and understand sources of electron beam motion; (3) characterization of the SPEAR3 vacuum chamber impedance to better understand beam stability with high stored current; (4) improving beam diagnostics for experimentally probing SPEAR3 nonlinear optics, the understanding of which improves our ability to predict and control accelerator performance when adding new insertion devices or pushing toward lower emittance; (5) initial testing of a laser-assisted photocathode mode of operation of the injector electron gun, which successfully showed we provide higher injector bunch charge to support top-off injection; (6) improvements of the SPEAR3 injection kicker magnet waveforms to minimize the perturbation of the stored beam seen by photon users during top-off injection; (7) an upgrade of the booster-to-SPEAR injector transport line, which will significantly reduce the injected beam size and reduce losses during top-off injection; (8) improved booster tunnel ventilation to handle the increased heat load associated with top-off injector operation; (9) improved feedback systems for enhancing the stability of the injector linac beam; and (10) improved diagnostics throughout the injector complex.

Many of the beam line R&D developments have been dominated by what has been required for beam line upgrades and construction of new beam lines. Developments beyond what are required for new beam lines include: (1) pitch-feedback system to stabilize the mirrors that focus x-rays onto the sample; (2) water temperature stabilization for the mirror cooling systems; (3) design and implementation of a motor control/data acquisition system to allow for continuous fluorescence data collection during rapid scanning of samples; (4) development of automation and remote data collection capabilities for macromolecular crystallography; (5) development of a unified interface and data collection hardware and software suite that provides uniformity between SSRL beam lines. This latter development has been critical in allowing the small SSRL staff to effectively manage a large number of beam lines and be able to provide outstanding user support.

Quality of the Process Used to Allocate Facility Time to Users

SSRL has had and continues to have an exemplary system for allocating beam time in which user proposals are sent out for peer review, followed by rating by an external review panel of experts. This process has served SSRL well for many years and discussions with the SSRL users executive committee have indicated that users feel this is a fair process. However, as fields change, it has become apparent that different fields need slightly different approaches. In particular, some fields need rapid access modes to satisfy rapidly changing needs and SSRL management has been sensitive to these needs. This has resulted in the institution of rapid access mechanisms for macromolecular crystallography, XAS, biological small angle x-ray scattering, XAS imaging and materials scattering.

NOTEWORTHY PRACTICES

Unified Beam Line Hardware/Software Solutions

The ability to have a well defined set of hardware and software solutions for the SSRL beam lines has allowed our small scientific staff to support a large number of beam lines and provide high quality service to our users.

SSRL Proposal Review Process

The use of peer review and a proposal review panel has provided for a high quality process for rating proposals and assigning beam time at SSRL with a very low number of appeals to the ratings from users (less than one per year).

High Level of User Satisfaction

SSRL maintains a very effective user support program as evidenced by the consistently high level of user satisfaction in the end of run reports. This is also illustrated by SSRL's successful 2008 triennial review in which Pedro Montano writes in his transmittal letter[1] of May 21, 2008: *"The SSRL facility has a long standing reputation of outstanding user support. Data from user surveys indicates that they are highly satisfied with the user experience at SSRL. SSRL staff is responsive to user needs and individual staff members often go beyond the call of duty to assist users in obtaining data. Anecdotal evidence suggests that no other light source facility provides the typical level of user support that is traditional at SSRL."*

OPPORTUNITIES FOR IMPROVEMENT

SSRL Proposal Review Process

Although proposal submissions are via the web, the current proposal submission and review process requires a significant amount of manual intervention. Development of a modern web-based system would greatly improve and streamline the process. This has been partially addressed in FY08, but is incomplete.

Objective 2.4 Utilization of Facility to Grow and Support Lab's Research Base and External User Community

SSRL provides research facilities that are used by a broad-based scientific community. This is evidenced by the different types of beam lines that are made available to users. A partial list below includes the following facilities and their associated user communities.

Macromolecular Crystallography

This area of research has the most number of beam lines at SSRL and is internationally recognized for the quality of the facilities and the scientific program brought by the users, as evidenced by the 2006 Nobel Prize in chemistry award to Roger Kornberg, a major user at SSRL for a number of years.

Correlated Materials

The main facility for this research is BL5, which is used to study the electronic structure of correlated materials and has garnered international recognition through its publications both for Stanford Faculty, staff and students as well as outside users. The Stanford work is led by Z.X. Shen and is described in the SIMES report.

Biological XAS

This program draws an international user community and is world class especially in the area of dilute XAS of biological systems, driven by in-house research and a significant user community. The activity is part of the SSRL structural molecular biology program, which is supported BER and NIH NCRR and receives very high marks in the joint BER/NIH peer reviews that take place every five years.

Molecular Environmental Science

This program, started by G. Brown of Stanford, opened up this field to the international community and is growing rapidly at SSRL. It is recognized for the quality of both in-house and user-based research and has contributed to the solution to a number of remediation problems of interest to the DOE.

Magnetism

A strong in-house research effort by J. Stöhr has led to developments that benefit the user community by the creation of user facilities in the areas of coherent imaging and in the future scanning transmission microscopy.

Materials Science

This is a broad area of research involving facilities to perform both x- ray diffraction and XAS. Research in this area includes studies of polymer materials, shape memory alloys and the fundamental studies of the structure of water. The research by users and in-house staff is very broad.

X-ray Microscopy

A new facility has been developed at SSRL to provide capabilities for imaging at 40 nm resolution, which is at the state-of-the-art. This is a new program with a growing user community and it illustrates the new directions in which SSRL is moving.

User Outreach Program

SSRL has an active user outreach program as evidenced by its workshops, including the SSRL School on Synchrotron X-ray Absorption Spectroscopy Techniques in Environmental and Materials Sciences: Theory and Application (May 2008) and the Stanford-Berkeley Summer School on Synchrotron Radiation (August 2008). These workshops are in addition to the annual SSRL Users' Meeting, which in FY08 included six workshops in the areas of:

- A Special Symposium on the Future of X-ray Science
- Introduction to Synchrotron Radiation Techniques
- Scientific Opportunities for Studying Laser Excited Dynamics at the LCLS
- X-ray Absorption Near Edge Structures (XANES) Spectroscopy: Data Collection, Analysis and Simulation
- New Opportunities in Microfocusing, Wednesday, October 3, 2007
- New Opportunities in Imaging and X-ray Microscopy, Wednesday, October 3, 2007

With the advent of the LCLS, starting in FY07, the Users' Meeting is held jointly with the LCLS to insure cross-fertilization of ideas between the two areas. SSRL also has a very active Users' Organization whose executive committee meets 3–4 times per year and provides important input on user issues, which it obtains for the user community as a whole through individual interactions and user surveys.

NOTEWORTHY PRACTICES

Strong Engagement of User Community

SSRL takes a proactive approach to engaging the user community through formalized channels including regular meetings with the SSRL Users Organization Executive Committee (SSRLUOEC) as well as scientific and technical workshops to provide input into SSRL's planning process. One example of proactive steps taken by the SSRLUOEC is the 2008 user survey which covered areas ranging from proposed scientific and operational initiatives to user satisfaction and desired facility improvements. Such input is taken seriously and discussions between SSRL management and the SSRLUOEC are used to evaluate suggested improvements.

B ➤ LCLS

The LCLS project ($420M TPC) is constructing an x-ray free-electron laser user facility at SLAC. LUSI is a "major item of equipment" project ($60M TPC) which will create experimental instruments for three of the six available experimental areas within the LCLS facility. In FY08, the LCLS directorate was created to deliver the LCLS user facility mission. In addition, LCLS construction and LUSI have a single project management organization. The directorate now has a framework within which LCLS operations, LCLS construction, LUSI and future projects can be placed to make best use of directorate resources. As part of the reorganization, the LCLS directorate has created an Experimental Facilities Division (EFD) to manage the transition of newly-constructed facilities to operations status. This division has formulated a user access policy and sponsored a call for proposals for first LCLS X-ray experiments in 2009.

The LCLS construction project is >85% complete as of August 2008. During FY08, an extended continuing resolution funding situation caused DOE-BES to direct a re-baseline of this project. The re-baseline schedule retains the original goal of achieving the capability for early XFEL science in FY09, but delays some project work and moves the project completion date to July 2010. The project meets or exceeds the requirements of DOE O413.3A with recognition of the earned value management system (EVMS), approved baseline change control, acquisition and project execution planning and performance reviews and reporting.

Construction of conventional facilities is on schedule. Safety statistics show a favorable trend, a reversal from a year ago. Management walks of the construction site, in addition to DOE/SSO walks, have provided positive reinforcement and demonstrated commitment to the safety of the workers. During FY08, the responsiveness of the general contractor (GC) proved to be inadequate, which warranted a request by LCLS for management changes. The resulting changes led to improved performance by the GC. It has now been recognized that contract incentives and flow-down requirements were not adequate to ensure that appropriate incentives were in place to hold the CG accountable for performance. This lesson will be applied to future construction projects.

The LUSI MIE Project has fulfilled all requirements for CD-2 and is expected to receive approval of the project baseline in October 2008. LUSI is >9% complete.

Objective 2.1 Provide Effective Facility Design(s) as Required to Support Laboratory Programs

Effectiveness of Pre-Conceptual R&D and Design for Life-Cycle Efficiency

- Instruments are designed for versatility and ease of upgrade
- Designated external instrument teams review and accept physics requirements

Leverage of Existing Facilities On Site

- Use of existing SLAC linac as LCLS accelerator

- LCLS and LUSI use same finance controls, procurement, quality assurance, and ES&H resources
- Matrix support of LCLS and LUSI for controls, engineering, detector development, radiation physics and data management
- LUSI has been completely integrated into the LCLS directorate organizational structure and uses standard LCLS project management procedures

Delivery of Accurate and Timely Information

- LUSI began reporting against the proposed project baseline in April 2008
- LUSI secured concurrence on instrument physics requirements from external instrument teams
- LUSI worked closely with LCLS construction to generate far hall hutch specifications

Ability to Meet the Intent of DOE O413.3A

- Postponed LUSI baseline review from May to August, improving CD-2 preparation by combining CD-2a and CD-2b into a single CD-2
- Three LUSI instruments brought to design maturity for CD-2 review August 2008
- Office of Project Assessment review has recommended approval of CD-2 for LUSI

NOTEWORTHY PRACTICES

- LUSI basis-of-estimate methodology incorporates lessons learned from LCLS and SNS
- Instrument team leaders and technical configuration control committee provide external technical advice
- LUSI cooperating with LCLS experimental operations to coordinate installation and transition to operations
- MIL-STD-882D, Standard Practices for System Safety, employed for hazard analysis
- LUSI worked closely with the DOE-SSO to develop a tailored project execution plan and schedule which meets the intent of DOE O413.3 and allows flexibility to provide an early science capability for the first two instruments on a fast-tracked schedule

OPPORTUNITIES FOR IMPROVEMENT

- Formalize roles and responsibilities of Instrument Team Leaders, Instrument Scientists and the LUSI Line Managers in the PEP
- Continue improving the integration between LCLS and LUSI projects

Objective 2.2 Provide for the Effective and Efficient Construction of Facilities and/or Fabrication of Components

Adherence to DOE O413.3A

- LCLS received DOE Office of Engineering and Construction Management (OECM) certification of project EVMS in FY08

Fabrication of Facility Components

- FY08 linac component fabrication and system installation and integration activities have been meeting project baseline schedule and milestones
- S-band photocathode gun is world’s best FEL electron source
- Undulator vacuum chamber met stringent tolerances
- State-of-the-art x-ray mirrors have met figure specifications
- X-ray pixel array detector prototype has met all its sensitivity and noise goals

Construction Schedule and Budget

- FY07 continuing resolution triggered LCLS re-baseline
- Revised baseline will permit early science at LCLS in August, 2009
- The LCLS linac is complete and commissioned. Remaining LCLS construction activities are on track for project completion by July, 2010
- LCLS construction project has “schedule performance index” of 1.00 and “cost performance index” of 1.01
- LCLS construction project contingency is 42.4% of the estimate to complete
- Conventional facilities construction is >90% complete
- Substantial completion of conventional construction is anticipated by November, 2008
- Approved change orders amount to about 5% of contract award values

NOTEWORTHY PRACTICES

- TEVMS software tool developed for LCLS praised by review and surveillance teams
- LCLS “advance procurement planning” spreadsheet used for critical procurements
- Partnership in safety oversight with SLAC, DOE/SSO and Turner Construction
- Contractor’s work safety recognition programs (Safety Stars)

OPPORTUNITIES FOR IMPROVEMENT

- Structure future construction contracts to create incentive for general contractor to meet LCLS, SLAC and DOE safety expectations
- Structure construction contracts with interim milestones, with specific consequences if milestones are not achieved
- Exercise owner’s rights in writing at first opportunity for construction activities
- Maintain centralized thorough project document control for construction documentation
- Minimize construction change orders
- Sufficient time and resources must be devoted to next bottoms-up cost estimate
- Procedures for funds transfer to project partners at other DOE labs must be improved

Objective 2.3 Provide Efficient and Effective Operation of Facilities

Availability, Reliability and Efficiency of Facility

- In FY08 commissioning, LCLS linac availability was >91%
- LCLS gun laser availability >99% in FY08
- Accelerator improvements over the next three years have been identified and prioritized
- Staffing plans to provide support of the experiment program in place

Degree the Facility is Optimally Arranged to Support Community

- LCLS directorate has created an organization geared to optimally support operations, scientific user program and R&D
- Electron beam properties already meet or exceed project goals
- New operating modes enabling new science have been developed

R&D is Conducted to Develop/Expand the Facility Capabilities

- SLAC has initiated strategic laboratory-directed R&D for 2009 and beyond
- LCLS directorate work breakdown structure explicitly identifies these programs

Effectiveness in Balancing Resources Between Facility R&D and User Support

- LCLS user program will grow after start in August 2009
- New LCLS directorate structure helps balance resources

Quality of the Process Used to Allocate Facility Time to Users

- LCLS access policy presented to user community in FY08
- LCLS is evaluating the first group of experiment proposals
- 28 proposals were received, representing 200 scientists from 15 countries
- Proposal review panel named that will assess scientific merit of proposals

NOTEWORTHY PRACTICES

- Integrated LCLS accelerator, systems engineering, instrument science and business systems into an effective organization to meet operational reliability, performance and scientific and user needs
- LCLS implemented operations work breakdown structure
- Linac is developing new operating modes, extending scientific reach of LCLS

OPPORTUNITIES FOR IMPROVEMENT

- Must rapidly increase staffing for experiment support as planned
- Review plans for allocation of space to better accommodate LCLS operations support personnel
- Develop appropriate metrics to track effective operational performance
- Develop scope driven budget model for LCLS linac operations

Objective 2.4 Utilization of Facility to Grow and Support Lab's Research Base and External User Community

Science Capabilities

- LCLS received 28 proposals from 200 scientists in first call
- LCLS is probably 100% oversubscribed for its first operations run

Ultra fast Science Research Base

- LCLS coordinating with Photon Science (PS) directorate (PULSE and SIMES)
- PULSE has four faculty members with research interests in LCLS
- PS is targeting hires in theoretical chemical dynamics and other areas for which LCLS will be a source of scientific results
- Members of the PS faculty participate in soft x-ray materials science (SXR) collaboration, which will build a new instrument for LCLS

Resident Research Community

- LCLS instrument team members are recognized leaders in their fields
- LCLS operations is expected to attract long-term visiting scientists to SLAC

Balance of access by internal and external user communities

- 120 of the first 200 authors of proposals for the first LCLS run are from research institutions outside the United States

Outreach to the Scientific Community

- First LCLS/SSRL user meeting held in FY08
- LCLS instrument teams meet at SLAC semiannually
- LCLS workshops have proven very successful in encouraging use of LCLS

NOTEWORTHY PRACTICES

- Two LCLS Proposal Writing Workshops took place in FY08
- The joint SSRL-LCLS user meeting encourages a unified view of photon science at SLAC while promoting cross-pollination of two distinct user communities

OPPORTUNITIES FOR IMPROVEMENT

- Plan to provide lab office space to host LCLS scientific staff along with visiting scientists
- Look for ways to accelerate the commissioning of new LCLS instruments
- Increase the breadth of the LCLS science by creating a sixth scientific instrument

C ➤ PULSE

Objective 2.1 Provide Effective Facility Design(s) as Required to Support Laboratory Programs

PULSE is fully engaged with the PULSE Institute construction project. We have been involved in specifying the properties of the lab, value engineering for cost reduction and safety engineering.

Objective 2.2 Provide for the Effective and Efficient Construction of Facilities and/or Fabrication of Components

PULSE has no direct role in the construction of our laboratories, since this is done under contract by an outside firm. However, we are directly involved in the design and construction of all of our instruments, including optical parametric amplifiers, HHG generators, spectrometers, molecular beams, particle charge, energy and spin detectors, imaging systems and computer-controlled data acquisition. We are providing information that enables the efficient construction of our new laboratories in B40.

Objective 2.3 Provide Efficient and Effective Operation of Facilities

PULSE does not operate user facilities.

Objective 2.4 Utilization of Facility to Grow and Support Lab's Research Base and External User Community

PULSE has helped create new capabilities to grow the external user base of both SPEAR3 and LCLS. In the case of SPEAR3, our major efforts have been in the construction of a laser system that can be used on beam lines for pump-probe spectroscopy. This is a new capability for SSRL.

PULSE is also working to grow a new community of users for LCLS through, for example our series of ultrafast x-ray summer schools.

We are active users of LCLS: we are on eight of the initial proposals for the AMO end station at LCLS and will also contribute a substantial number of new proposals for the soft x-ray end station.

D ➤ SIMES

Objective 2.1 Provide Effective Facility Design(s) as Required to Support Laboratory Programs

SIMES has been very successful in making the scientific case to design new facilities required to support the program. This has been the case for small scale instruments needed for specific projects and major infrastructure instruments.

NOTEWORTHY PRACTICES

SIMES has been the lead organization to make the scientific case for soft x-ray activities at LCLS. We have facilitated an international consortium (including SU, the German government and others) that provides over $4M non-federal funding for soft x-ray research. The scientific and technical case for a soft x-ray beam line has been accepted by LCLS management; it will allow for a very wide range of new scientific activities that will enrich the science at LCLS.

SIMES has also been very successful in making the case for and starting a new computational facility at SLAC. This facility will be the focal point or nucleation center to develop computational simulation programs to support photon science research, thereby adding significant value to the experimental results.

OPPORTUNITIES FOR IMPROVEMENT

Since its inception, SIMES has operated in an environment where the capital budget of the program has been quite stressed. We have a developed program plan, but not all aspects are currently funded. We need a new strategy to overcome this problem.

Objective 2.2 Provide for the Effective and Efficient Construction of Facilities and/or Fabrication of Components

SIMES provides effective scientific leadership and technical guidance for the construction of both the LCLS soft x-ray facility and the computation facility. In addition, SIMES is developing some unique experimental measurement capabilities, as well as materials synthesis facilities.

NOTEWORTHY PRACTICES

- Soft x-ray facility design is well underway; successful effort to form an international consortium; implementation on track.
- The first phase of SIMES computational facility was completed on time and on budget and is already producing results. The second phase performance enhancement is underway.
- SIMES developed a strong materials discovery and synthesis program that enabled a number of discoveries.
- SIMES developed the world's most sensitive Sagnac interferometer for magneto-optic measurements.

OPPORTUNITIES FOR IMPROVEMENT

There is significant need for materials characterization facilities for all researchers at SIMES. Such facilities will put our research at an even higher level. The lack of critical mass prevents us from developing some of these needed capabilities as the materials program is still relatively small. We need to develop a more adaptable strategy to build up shared enabling facilities.

Objective 2.3 Provide Efficient and Effective Operation of Facilities

SIMES runs its own computational facility and experimental stations both at the user facilities (SSRL and LCLS) at SLAC and in our own laboratories.

NOTEWORTHY PRACTICES

By bringing very talented staff and young people to run these facilities, SIMES is able to operate its facilities very efficiently.

OPPORTUNITIES FOR IMPROVEMENT

SIMES would like to bring more professional staff to run some of its key shared facilities for SIMES searchers. We need to change our personnel mix to have more staff, in addition to students and faculty principle investigators.

Objective 2.4 Utilization of Facility to Grow and Support Lab's Research Base and External User Community

SIMES is not currently a unit based at the SLAC facility, so it does not support the user program. However, the unique capabilities it has developed make its program base stronger and enable its researchers to compete and grow the program.

NOTEWORTHY PRACTICES

SIMES will have a dedicated soft x-ray beam line offshoot from the LCLS, which will be a unique research program in the world that will enable pioneering experiments in soft x-ray science. Expertise in SIMES on soft x-ray science will be critical to ensure the proper configuration and implementation of these experiments.

OPPORTUNITIES FOR IMPROVEMENT

New experimental stations at beam lines and enhanced materials capability will enrich SIMES' program. More effort (including recruitment) is needed to leverage SLAC's user facilities for programs, especially in areas of materials scattering and imaging.

HEP

F ➤ Astrophysics

Objective 2.1 Provide Effective Facility Design(s) as Required to Support Laboratory Programs

The LSST experimental work has been successfully migrated to laboratories on campus.

NOTEWORTHY PRACTICES

Successful collaboration with potential spacecraft contractor over SNAP.

OPPORTUNITIES FOR IMPROVEMENT

Integrate the LAT work, which is spread between two quite separate buildings.

Objective 2.3 Provide Efficient and Effective Operation of Facilities

The major facilities with which the astrophysics program is involved are the Fred Kavli Building and Building 84. Managing the use of these buildings so members of and visitors to the astrophysics program can work efficiently is a major challenge as the space is seriously oversubscribed. This management task has been performed very well.

NOTEWORTHY PRACTICES

Established rules for allocating space and executed them appropriately.

OPPORTUNITIES FOR IMPROVEMENT

Inadequate meeting space leads to anticipated double bookings of the auditorium and lecture theaters.

G ➤ *B*-Factory

Objective 2.1 Provide Effective Facility Design(s) as Required to Support Laboratory Programs

BABAR

The campaign undertaken over the last several years to maintain high data taking efficiency, in the face of luminosity that has increased to four times over the initial design, reached fruition in the early part of FY08. The headroom provided by these planned upgrades allowed development of loose event trigger configurations required to address key physics issues in the narrow Υ resonance decays. Details are discussed in the next section.

Objective 2.3 Provide Efficient and Effective Operation of Facilities

BABAR

The ultimate measure of success of operations at a high luminosity 'factory' accelerator like PEP-II is the efficient acquisition of high quality data.

- The experiment is live ('eyes open') 97% of the time that PEP-II is providing colliding beams to the experiment.
- This efficiency of operations is matched by the high efficiency in recognizing and acquiring ('triggering on') events of interest.
- Triggering efficiencies for topologies of interest at the Υ(4S) are over 90% and for the hallmark core physics of *BABAR*, states used for CP violation studies, it is close to 100%.

The small data-taking inefficiency of 3% is due to a combination, in equal parts, of unscheduled detector down time and of data acquisition dead time. The down-time fraction has remained at this low level even though many of the detector components have been in operation since 1999.

The plan, which was executed over several years leading up to FY08, to control dead-time due to the readout system bore fruit during data taking on the narrow Υ resonance during FY08. Ingredients for improvement from prior years include:

- Trigger upgrade: incorporate longitudinal information into the tracking trigger.
- DIRC (Cherenkov ring image detector): upgrade read-out electronics to improve rate handling capability.
- Drift chamber: upgrade readout electronics to perform feature extraction on the detector.
- Electromagnetic calorimeter: feature extraction software performance optimized, allowing lowest level trigger rates up to 7kHz.

In preparation for the final data-taking run by the experiment in FY08, operational improvements were made to two systems:

- Silicon vertex tracker: adjust thresholds to ameliorate high electronics occupancy.
- DIRC: simplification of read-out module code to eliminate dead-time issues.

New challenges were posed by the physics program on the narrow Υ resonances: decay modes of interest for key new and precision physics searches (η_b inclusive search; Υ(1S) decays to invisible states or a light Higgs) were not triggered with high efficiency using the Υ(4S) triggers. It was necessary to quickly develop additional new trigger configurations. These triggers improved efficiencies from low (18% and ~0%) to acceptable (80% and 22%) for difficult modes. These loose triggers provided a challenge in times of high backgrounds; rates for lowest level triggers went as high as 7kHz. However, because of the readout improvement campaign, the *BABAR* data acquisition system was able to cope with the rates with little increase in dead-time.

NOTEWORTHY PRACTICES

PEP-II

The PEP-II staff developed in advance computer algorithms that could change the center of mass collision energy of the collider in real time, which improved running efficiency markedly during the short FY08 run.

Objective 2.4 Utilization of Facility to Grow and Support Lab's Research Base and External User Community

BABAR

The success of the science goals of the *BABAR* experiment has been primarily dependent on the efficient operation of the PEP-II accelerator at SLAC, its ability to deliver highest possible luminosity in electron-positron collisions and the experiment's ability to record the data with high efficiency. These realities have served as the driving forces in keeping accelerator at the leading edge of the luminosity frontier and the data collection efficiency of the experiment at nearly 97% over its lifetime. The experiment also makes maximal use of the computing facilities at SLAC to reconstruct and perform the physics analysis of its data set.

The data-taking phase of the *BABAR* experiment was concluded on April 7, 2008. Last year, the collaboration carried out an extensive study to understand and design a computing and analysis program for performing physics measurements with *BABAR's* final data set beyond the data-taking phase of the experiment. The resulting program is based on the utilizations of the computing facilities at the laboratory, together with *BABAR's* computing resources at the Tier-A centers in Europe, to allow for an intense analysis period of data analysis between 2009 and 2010, followed by a steady analysis period lasting several years more. The latter steady analysis period and more generally the future of *BABAR* beyond 2010, is the subject of focus of a task force launched at the end of FY08.

Since the start of the experiment, the success of the science program always depended on the collaboration's ability to organize its computing resources (including manpower) throughout all its institutions and most notably from its Tiers-A centers; this was true also for FY08 and it will remain true until the end of the intense analysis period when computing resources will be provided only by SLAC.

H ➤ Elementary Particle Physics

Objective 2.1 Provide Effective Facility Design(s) as Required to Support Laboratory Programs

Development of Silicon Detector Concept for the ILC

The SiD is a linear collider detector concept optimized for the physics opportunities of the International Linear Collider (ILC) or any future energy frontier electron-positron collider. The concept features high resolution vertex measurement; momentum measurement primarily by silicon strip detectors in a 5T solenoidal field; high segmentation silicon-tungsten electromagnetic calorimetry; hadronic calorimetry with an iron/resistive plate chamber (RPC) sampling detector and muon identification in the solenoid flux return by RPCs. The design emphasizes precision jet energy measurement by particle flow algorithm techniques; high precision vertexing; robustness to machine backgrounds; and design for convenient push-pull interchange with a second detector.

A SLAC group is leading the development of the overall concept and is engaged in vertex detector sensor development; tracker sensor development; electromagnetic calorimeter design; solenoid design; flux return design; forward calorimetry development; machine detector interface development; software systems; particle flow algorithm development; simulation development; and benchmarking.

The group draws extensively on experience from the world's first and only linear collider, SLC and from the SLD detector at the SLC. It broadly works on the integrated detector design strategy; critical enabling R&D ranging from advanced electronics to superconductor design; and broad physics capability strategy.

The major thrust in 2008 is preparation for the Letter of Intent (LOI) to the ILC management, due in early 2009. This LOI is expected to be the basis for the validation of SiD as a technical concept suitable for further development and for identifying common detector R&D and machine-detector interface issues.

This year SLAC has participated as authors in the following documents:

- ILC Reference Design Report Volume 4 – Detectors
- ILC Reference Design Report: ILC Global Design Effort and World Wide Study
- An electromagnetic calorimeter for the silicon detector concept (Pranama 69:1025-1030,2007)
- Silicon Detectors at the ILC (STD6 Hiroshima)

EXO Double-Beta-Decay Experiment

The Enriched Xenon Observatory (EXO) is an experiment designed to use a large quantity (>1 ton) of Xenon enriched in the Xe136 isotope as both a decay and detection medium for neutrinoless double-beta decay. The double beta decay process,

Xe136 to Ba136++ + e- + e- (+ 2 neutrinos)

can proceed in the two neutrino (2nubb) mode expected within the Standard Model (already observed in several nuclei other than Xe136), or possibly in the neutrinoless (0nubb) mode. If neutrinos are Majorana particles (in which case neutrinos are their own antiparticles) the 0nubb process is expected to occur at a rate proportional to the square of an "effective" neutrino mass and hence its observation would serve as both a mass measurement and as the first demonstration that Majorana neutrinos occur in nature.

The candidate events are to be detected in a liquid xenon time projection chamber (TPC) that reconstructs the location and energy of the event with sufficient energy resolution to distinguish 0nubb events from 2nnbb events and from backgrounds. In addition, non-bb backgrounds can essentially be eliminated by identifying the barium daughter nucleus of double beta decay on an event-by-event basis (barium “tagging”).

A prototype experiment, EXO-200, using ~200 kg of enriched xenon without a barium-tagging capability is presently under construction. This phase I experiment will be placed in the DOE-operated underground facility Waste Isolation Pilot Plant (WIPP) in Carlsbad NM.

Progress in FY08 year includes:

- A modular clean room facility, which includes cryostat, refrigeration, xenon handling, UPS power supply, data monitoring and control systems previously assembled and tested at the W. W. Hansen Experimental Physics Laboratory (HEPL) Endstation III on Stanford campus, was disassembled, shipped to WIPP and reassembled underground. Recommissioning of the apparatus will begin in November, 2008.
- Construction and assembly of the liquid xenon TPC detector construction continues at SLAC and Stanford. The TPC electronics are complete and under test.
- Data links within WIPP and from WIPP to SLAC are being installed and commissioned.
- Installation of the cosmic ray veto system surrounding the clean room at WIPP.
- R&D for barium tagging continues at Stanford and other collaborating institutions and at on a smaller scale, at SLAC.

The EXO collaboration has published several papers in either Nuclear Instruments and Methods (NIM) or the Physical Review covering technical issues relating to the R&D for EXO200, the R&D for barium tagging, or the radiopurity qualification of materials used for construction of the apparatus. In FY08, one additional paper appeared in NIM.

In the coming year, we expect data taking with EXO-200 to commence. This will follow completion and testing of the TPC, the TPC electronics at SLAC and Stanford and then shipping and installation of the TPC in the clean room at WIPP. Xenon purity, electronics/noise, radio-source calibration and overall detector performance, including background levels, will be characterized before first results.

Objective 2.3 Provide Efficient and Effective Operation of Facilities

ATLAS at the LHC

The Large Hadron Collider (LHC) will be the flagship high energy frontier facility for the next decade, with opportunities for major discoveries that could fundamentally change our understanding of nature. The LHC is designed to elucidate the mechanism for creation of mass, while also providing access to direct production of physics beyond the Standard Model. Two large international collaborations, ATLAS and CMS, have been formed to design, construct, commission and operate the main detectors for energy frontier LHC physics. SLAC has been a member of ATLAS since July 2006, with initial involvement in the pixel detector, high level trigger (HLT) and simulation. The laboratory is also host to a Western Tier 2 computing center for U.S. ATLAS.

The present SLAC ATLAS team consists of 2 faculty members and 10 staff members with research time on ATLAS of at least 50%, 4 postdoctoral fellows and 3 Ph.D. students. One full-time staff person supports the ATLAS Tier 2 center. Several additional physicists and engineers have recently joined the ATLAS effort, following a proposal to enlarge the scope of SLAC support of U.S. contributions to the operation and physics exploitation of ATLAS and to begin engaging in upgrade R&D activities aimed at the Super LHC.

The main ATLAS activities in FY08 include:

- Final assembly and testing of the Pixel System during assembly and commissioning of the installed device both in standalone mode and integrated into the ATLAS data acquisition system.
- Assembly of a test stand and creation of a software environment for development of the Pixel System Readout Drivers (ROD) as part of the Data AcQuisition (DAQ) system.
- Studies of Pixel System performance, alignment and tracking.
- Ongoing development and support for a client-server configuration mechanism for the HLT farm, which hosts the Level 2 Trigger and the Event Filter.

- Development, in collaboration with CERN, of a robust MySQL technology-independent protocol for the HLT configuration database.
- Development of a partial-event build capability to allow flexible and high rate acquisition of detailed calibration data by detector subsystems.
- Development of online monitoring and distribution of primary vertex information to the HLT.
- Contributions to the development of HLT trigger algorithms, including substantial reductions in CPU consumption for the liquid argon calorimeter frontend energy sums and to b-tagging algorithms for the L2 trigger.
- Debugging and commissioning of the read out drivers for the CSC muon system.
- Participation in a program to improve the speed of the main ATLAS simulation program and direct contributions to the simulation code for the muon system.
- Participation in the development of an event overlay capability for the ATLAS simulation.
- Further expansion and ongoing support for the ATLAS Tier 2 center.
- Initiation of R&D for future upgrades to the ATLAS tracking system, including phase 1 development of a capability for using CO2 as a coolant, studies of data transmission options for high speed radiation hard applications, collaboration of the development of prototype tracking system stave designs and participation in 3D pixel device beam tests.
- Development of a foundation for future physics analysis through improvements to physics signature reconstruction efforts, including new approaches to jet reconstruction, track-based jet energy scale corrections, semileptonic b-jet energy scale corrections, in situ measurement of jet energy resolution, jet-vertex identification, tau lepton identification and trigger and tracking studies for long-lived particle signatures.

Goal 3 Efficient and Effective Science and Technology Program Management

The Contractor provides effective program vision and leadership; strategic planning and development of initiatives; recruits and retains a quality scientific workforce; and provides outstanding research processes, which improve research productivity.

The weight of this goal is 20%.

The Provide Effective and Efficient Science and Technology Program Management goal shall measure the Contractor's overall management in executing S&T programs. Dimensions of program management covered include: 1) providing key competencies to support research programs to include key staffing requirements; 2) providing quality research plans that take into account technical risks, identify actions to mitigate risks; and 3) maintaining effective communications with customers to include providing quality responses to customer needs.

BES/BER (63%)

Element		Letter Grade	Numerical Score	Objective Weight	Weighted Score	Total Score
3	Efficient and Effective Science and Technology Program Management					
3.1	Provide Effective and Efficient Stewardship of Scientific Capabilities and Program Vision	B+	3.4	40%	1.4	
3.2	Provide Effective and Efficient Science and Technology Project/Program Planning and Management	B+	3.4	30%	1.0	
3.3	Provide Efficient and Effective communications and Responsiveness to Customer Needs	B+	3.2	30%	1.0	
					BES/BER Science and Technology Score	3.4
					BES/BER Funding Weight (63%)	**2.1**

HEP (37%)

Element		Letter Grade	Numerical Score	Objective Weight	Weighted Score	Total Score
3	Efficient and Effective Science and Technology Program Management					
3.1	Provide Effective and Efficient Stewardship of Scientific Capabilities and Program Vision	B	3.0	40%	1.2	
3.2	Provide Effective and Efficient Science and Technology Project/Program Planning and Management	B+	3.4	40%	1.4	
3.3	Provide Efficient and Effective communications and Responsiveness to Customer Needs	B+	3.1	20%	0.6	
					HEP Science and Technology Score	3.2
					HEP Funding Weight (37%)	**1.2**

Total Goal 3 Score: 3.3 (B+)

BES/BER

A ➤ SSRL

SSRL provides for effective and efficient science and technology program management by developing state-of-the-art experimental resources for our user community, as well as scientific and technical staff to support these efforts. In addition, the scientific and engineering staff is encouraged to pursue new technical directions that will bring additional capabilities to the laboratory. Research plans are developed in conjunction with the wider user community and through its SSRL User Organization Executive Committee (SSRLUOEC) and are validated through user workshops, technical reviews and through the SSRL SAC.

Objective 3.1 Provide Effective and Efficient Stewardship of Scientific Capabilities and Program Vision

Efficiency and Effectiveness of Joint Planning (e.g., Workshops) with Outside Community

SSRL actively sponsors workshops to bring together user communities to develop new research directions and establish cooperation with other laboratories. For example, SSRL holds a joint summer school with the ALS to train students and post docs in the use of synchrotron radiation and SSRL held a school on Synchrotron X-ray Absorption Spectroscopy Techniques in Environmental and Materials Sciences. The SSRLUOEC periodically performs user surveys and SSRL management works with the user community to address any needs or request that emanate through this process.

Articulation of Scientific Vision and Development of Core Competencies, Ideas for New Facilities and Research Programs

SSRL's scientific vision is articulated through its strategic plan, which is developed with wide input. This plan serves both as a starting point to define SSRL's present core competencies and define areas for future growth. These areas include development of advanced spectroscopy and diffraction, x-ray microscopy and microspectroscopy and time resolved research that will complement the LCLS. In addition, it describes the formation of a task team to develop long range plans for new photon sources at SLAC.

Ability to Attract and Retain Highly Qualified Staff

In reviews by the DOE and by the SSRL SAC, SSRL has received the strong message that the scientific staff at SSRL is of very high quality. Recognizing this fact, SSRL created a scientific staff task force on retention and promotion to help identify ways to better retain and hire excellent staff. This task force provided a report to the SSRL director, who has implemented a number of the recommendations that included creation of multiple levels for the scientific staff ranging from entry level through a career position, senior and distinguished positions, creation of groups for the beam line scientists where common interests could be discussed and the availability of funds for these groups to perform small upgrades to the experimental stations. The quality of the staff scientists is also evidenced by the number of advisory committees on which they serve, as previously noted in this report.

NOTEWORTHY PRACTICES

Creation of Advancement Paths for Scientific Staff

The creation of multiple levels for the scientific staff was an SSRL initiative that was adopted by the SLAC site. In addition, SSRL made it possible for scientific staff to be principal investigators on DOE proposals. This has given the scientific staff significant new possibilities for their career path. This fact was confirmed by the by comments from the 2008 triennial review in which Pedro Montano writes in his transmittal letter[1] of May 21, 2008: *"The implementation of four different scientific staff levels and the ability to serve as principal investigators on DOE proposals has significantly enhanced the scientific staff's career development opportunities."*

Objective 3.2 Provide Effective and Efficient Science and Technology Project/Program Planning and Management

SSRL plans in a number of different ways. For example, long-term technical and scientific planning is done through the strategic plan, which is then used to develop the plans that are incorporated into the annual field work proposal. These plans are updated at regularly held senior management meetings in which the current needs of the facility are integrated with the budget. Project budgets are reviewed on a regular basis and adjustments are made in spending profiles and expected project completion dates to reflect the budget realities.

Since SSRL is a user facility, much of the planning revolves around developing a running schedule that fits with the user needs as well as site needs for power outages and installation of new beam lines and facilities. SSRL has been very successful in running a large number of hours and limiting shutdowns to the minimum necessary only for beam-line installations. Facility upgrades are also carried out during these times, which in FY08 included seismic retrofit activities in Building 120 and various beam line and accelerator installation projects. Again, these activities required careful planning to not interfere with ongoing shutdown and insuring that they were completed in time for accelerator startup.

NOTEWORTHY PRACTICES

Building 120 Seismic Upgrade

Careful planning for the seismic upgrade for Building 120 resulted in a project that was performed safely, under budget and ahead of schedule without disrupting user operations.

Objective 3.3 Provide Efficient and Effective Communications and Responsiveness to Customer Needs

SSRL has had excellent communication with BES at a number of different levels. SSRL has responded to HQ requests for information thoroughly and in a timely fashion (and, in fact, in real time when a real time response is requested by HQ). SSRL management has worked with HQ to make sure that requests are sent to the right staff at SSRL so they receive prompt attention. SSRL prides itself in not letting requests “fall through the cracks.” There are excellent direct lines of communication between SSRL and HQ, as well as the program offices.

NOTEWORTHY PRACTICES

Successfully Meeting Technical and Management Challenges

SSRL has worked with DOE to meet a number of challenges including the completion of the SPEAR3 accelerator and beam line upgrades as well as the management changes within SLAC. This is reflected by comments from the 2008 triennial review in which Pedro Montano writes in his transmittal letter1 of May 21, 2008: *“The SSRL administration and staff should be commended for shepherding their facility through a number of challenging problems over the past several years. The main challenge has been in delivering on the SPEAR3 upgrade. Other important challenges include retaining their vitality during a relatively short period of time that has seen major management changes within SLAC and SSRL, startup of the LCLS project and budgetary strain. The SLAC and SSRL leadership demonstrated a strong united front aimed at making SLAC a world leader in photon science.”*

B ➤ LCLS

The LCLS directorate at SLAC has been created to manage the LCLS user facility. Its responsibilities include managing the LCLS construction project (building the main LCLS infrastructure) and the LUSI MIE project (building scientific instruments for LCLS), operating the LCLS facility to produce FEL x-rays and organizing and managing a user research program. In addition, the Directorate develops concepts for upgrade projects which will enhance the facility’s scientific capability.

To date, both the LCLS construction project and LUSI have met schedule and budget milestones and achieved technical goals. Project performance is closely monitored by external reviews and BES oversight. LUSI achieved its CD2 milestone goals in FY08.

The EFD, in anticipation of user operations next year, held workshops related to early LCLS science and sponsored an annual user Meeting. The directorate also collaborated with other Photon Science groups at SLAC to formulate coherent scientific and operations goals which have been incorporated in the SLAC business plan.

Objective 3.1 Provide Effective and Efficient Stewardship of Scientific Capabilities and Program Vision

Planning with Outside Community

- Annual LCLS/SSRL Users Meeting
- Workshops on High-Field Atomic Physics and Laser-Excited Dynamics in condensed matter
- Summer School on Ultrafast X-ray Science in second year at SLAC

Scientific Vision

- LCLS scientific and organizational goals included in SLAC business plan
- Concepts developing for expansion of the LCLS facility beyond the initial configuration

Development of Core Competency (LCLS User and Experimental Operations)

- First call for experimental proposals in FY08, for experiments in late FY09
- 28 proposals received, over 200 scientists listed as participants
- Proposal review panel named that will evaluate scientific merit of proposals

NOTEWORTHY PRACTICES

Development of Core Competency (LCLS User and Experimental Operations)

- LCLS and SSRL will share resources in user administration and user experiment support
- Will increase efficiency and reliability of user operations at both facilities

OPPORTUNITIES FOR IMPROVEMENT

Development of Core Competency (LCLS User and Experimental Operations)

- Sustained operations will require a timely and effective ramp up of staff.

Objective 3.2 Provide Effective and Efficient Science and Technology Project/Program Planning and Management

Quality of User Facility Strategic Plans

- Pre-operations accelerator R&D started in FY07 with commissioning of LCLS electron gun
- Expanded in FY08 to include entire LCLS accelerator system
- Accelerator performance has exceeded project baseline milestones
- LCLS directorate created to manage LCLS as an operating user facility
- Planning for LCLS future is reviewed by LCLS SAC

Adequacy in Considering Technical Risks

- LCLS and LUSI construction projects maintain risk registries that were reviewed monthly
- Commissioning of LCLS injector and linac has been very smooth
- Pre-operations R&D strategy was developed with extensive external advice and oversight
- Electron beam has met all performance goals to support LCLS mission

Synergy with Other Areas

- LCLS planning is coordinated with SSRL, PULSE and SIMES

NOTEWORTHY PRACTICES

- LCLS EVMS certified in FY08 by DOE OECM as being compliant with ANSI standard 748.

OPPORTUNITIES FOR IMPROVEMENT

Quality of User Facility Strategic Plans

- Organization must be updated as goals change from construction to operations
- Recognize LCLS near-term goal of starting user operations in late FY09
- Long-range planning should balance operations, upgrades and budget uncertainties

Objective 3.3 Provide Efficient and Effective Communications and Responsiveness to Customer Needs

Program Office Oversight

- Semiannual BES reviews of LCLS construction project and LUSI project
- LCLS management has weekly telephone conferences with BES project managers
- LCLS management meets with the Federal project director weekly
- LCLS management meets with the SLAC director twice per week
- Federal project director attends major LCLS and LUSI meetings
- Safety experts from the DOE/SSO tour LCLS construction sites weekly
- When events occur that could influence project performance, additional BES reviews are held

Determining Appropriate Contact

- LCLS organization chart delineates project line management roles and responsibilities

OPPORTUNITIES FOR IMPROVEMENT

- Continued emphasis must be maintained on timely communication between the LCLS directorate and DOE BES regarding the LUSI project, transition to operations and future LCLS upgrade options.

C ➤ PULSE

Objective 3.1 Provide Effective and Efficient Stewardship of Scientific Capabilities and Program Vision

Efficiency and Effectiveness of Joint Planning (e.g. workshops) with Outside Community

In FY08 as in FY07, PULSE sponsored a summer school on ultrafast x-ray science, bringing to SLAC experts in ultrafast science from the AMO, materials science and accelerator physics community together along with students to focus on opportunities for new science at LCLS and other accelerator-based short pulse x-ray sources. Workshops also continue to be held as part of the SSRL User's Meeting on ultrafast opportunities at LCLS. We worked with LCLS to bring the community of interested researchers together for proposal writing workshops during the proposal period this summer and will continue to push for such innovative workshops that help the community connect with LCLS.

Articulation of Scientific Vision and Development of Core Competencies, Ideas for New Facilities and Research Programs

Our core competencies are discussed in the PULSE proposal. We are now starting our renewal process and the first step is a total re-evaluation of the most exciting science opportunities. PULSE participated in last year's strategic planning process to define the future of SLAC. We are developing ideas for applying the power of the LCLS to technological areas of energy and information science, as well as basic materials processing and chemistry. Our experiments will probe the earliest time-scale electron dynamics in atoms and during chemical reactions and the development of electronic correlations in materials. Therefore we have also started a theory program to capture the insights derived from frontier experiments.

Ability to Attract and Retain Highly Qualified Staff

PULSE has even more successful this year than last in this aspect. We have recruited David Reis, a leader in the field of ultrafast x-ray science, to PULSE. We have also recruited Todd Martinez, a leader in ultrafast chemistry theory. Finally, we recruited Michael Bogan from LLNL, a physical biochemist who in now leading the effort to image nano-sized objects including biomolecules using LCLS diffraction.

Objective 3.2 Provide Effective and Efficient Science and Technology Project/Program Planning and Management

First and foremost, our planning is included in the PULSE program proposal to DOE. This proposal was reviewed both by DOE program managers in BES (including both the Materials and Chemical Sciences Divisions) and by anonymous peer reviewers selected by BES. The program was also reviewed by the Office of the Dean of Research at SU and by the Photon Science director at SLAC, since these two offices have joint formal oversight responsibility for PULSE. These anonymous reviews gave the center its highest rating for scientific merit. Subsequent reduced budgets reflected the restrictions demanded the governments failure to maintain the basic science budget for FY07 or FY08 and the limits this placed on any new programs in BES for these difficult years.

Revisions to the proposal following guidance from BES form the second official revision of our strategic plan. These included an increased role of the Stanford Office of Research in areas such as administrative support and the formation of an external advisory board. This required that we make some difficult decisions to advance areas of immediate interest to the material science and chemical science programs, while temporarily reducing our effort in source development. These decisions were made and a budget was successfully implemented approximately four weeks following notification of the approval of our program by DOE.

In FY08, we have had an opportunity to reinforce some elements of our strategic plan, which were not funded initially, by recruiting high profile faculty to Stanford. In particular, this has given us the opportunity to have programs in ultrafast condensed matter science (D. Reis) and ultrafast theoretical chemistry (T. Martinez). Reis has received base funding from BES and Martinez has initial funding from laboratory directed research and development (LDRD) at SLAC.

The fourth element of our strategic planning this year is the PULSE participation in site-wide EFRC and Energy Small Group Research initiatives from BES. We have added mission-specific ultrafast activities to two EFRC's and also have submitted two SISGR's to this year's competition.

Dealing with Technical Risks and Challenges

Our greatest challenge has been to deal with the lack of adequate laboratory space for ultrafast laser science on the SLAC site. To manage this challenge and mitigate the risk of reduced activity with no space, we have established off-site laboratories on the Stanford campus. The first of these were commissioned in FY07 in Varian Laboratory and the second has been commissioned in FY08 in Durand Laboratory. The physical infrastructure for these labs was financed by the Stanford management, with equipment and supplies from the ultrafast programs that preceded PULSE Center.

We have been actively involved in development of new laboratory space in B40 (Central Lab) to overcome this deficiency in our program. We successfully obtained approval by BES for renovation funds in the FY08 and FY09 budget plans for BES. SLAC appointed a project management team and PULSE personnel have been meeting with them and with architects and engineers on a weekly basis to build and keep to a timeline for successful completion of the renovations. Our decision to do this now is based on our analysis that early occupancy will enable us to avoid technical problems that may arise as we get closer to the start date for LCLS.

Synergy

PULSE has common research interests with many in the local and international community and we are working to build those ties to strengthen our research output, to leverage our research resources and to build a stronger future center. Our many research collaboration are listed in another section of this document and are also evident in the FY08 publication list, which includes co-authors for SSRL, SIMES and LCLS within SLAC; with Stanford Physics, Applied Physics, Chemistry and Engineering faculty, staff and students; and with other institutions in the U.S. and Europe.

Objective 3.3 Provide Efficient and Effective Communications and Responsiveness to Customer Needs

Discussions with BES over the PULSE program and budget have gone very well and have been very intense and interactive. We have been able to start the PULSE program in a difficult "no new start" continuing resolution environment and our output in our first years has been appreciated very much by our sponsors. In this case the challenge of good communication has been complicated by the fact that we are sponsored by two different divisions in BES and traditionally they have different points of contact within the lab.

E ➤ SIMES

Objective 3.1 Provide Effective and Efficient Stewardship of Scientific Capabilities and Program Vision

SIMES develops effective stewardship and program vision through review and strategic planning processes. In addition to DOE-BES reviews which occur every three years and the annual management review, SIMES conducts its own review and strategic planning with the assistance of its SAC. SIMES also has formed a management group to provide inputs for the director to priority setting for resource allocation. Working with its principle investigators and through consultation with SAC and DOE officers, SIMES has re-organized itself to better capitalize the current research opportunities.

The SAC of SIMES consists of renowned scientists and is chaired by Dr. E. Isaacs.

NOTEWORTHY PRACTICES

- SIMES has successfully invited and recruited top scientists to serve on its SAC.
- Through close consultation with DOE-BES program officers, SIMES has undergone a reorganization to better facilitate efficient stewardship of its multiple capabilities and strengthen its program. This has been a very important to help SIMES grow as well as address the BES call for programs to address society's clean, renewable energy needs. SIMES now has four research areas: X-Ray Science and Techniques, Quantum Materials, Interfaces and Catalysis for Energy Conversion and Storage and Carbon-based and Biomimetic Hybrid Materials.
- With the help of SU and DOE-BES, SIMES has made two strategic hires which critically strengthened needed areas in the program, e.g., computational simulations.
- SIMES received seed funds from SU which it was able to administer/direct to strategic areas of its program. One program has attracted BES funding through a peer review process.

OPPORTUNITIES FOR IMPROVEMENT

It would be great leverage to have a Nano-Science Center at SLAC that has cutting edge tools complementing the major accelerator based photon science facilities, which would be fertile ground for SIMES to expand its tools and programs in cutting edge research. SIMES should be more actively involved in the forward planning to make this happen. The very limited scope of the current program means that SIMES does not have the necessary depth in all the areas to which we aspire.

Objective 3.2 Provide Effective and Efficient Science and Technology Project/Program Planning and Management

With the help of its SAC and SLAC leadership, SIMES has developed a strategic plan to enhance its science program. It actively participates in a number of DOE's EFRC and team proposals. SIMES has also participated in SLAC's first LDRD program.

In addition, SIMES managers and researchers have also contributed to SLAC-wide major activities and initiatives, including senior personnel recruitment, space planning, strategy for future light sources, proposals for beam lines and stations at SSRL and LCLS.

We participate and contribute in national workshops and panels organized by DOE to help articulate scientific vision for the DOE science enterprise.

NOTEWORTHY PRACTICES

- Stewardship of the soft x-ray facility at LCLS–formation of international consortium, participation in the design and implementation of the experiment.
- New beam line proposals at SSRL–several major proposals submitted to DOE.
- Participate in the DOE call for EFRC initiative. Submitted two major EFRC proposals.
- Submitted three strategic team white papers to DOE.
- With funding from Stanford, SIMES held a successful seed competition and in turn organized successful seeds to submit proposals to DOE.

OPPORTUNITIES FOR IMPROVEMENT

To work with DOE in realizing the EFRC programs would enhance SIMES through the competitive proposal process and broadening of our materials research program via close collaborations with researcher from six University of California campuses. This should be more proactive in forming strategic collaborations in other focus areas.

Objective 3.3 Provide Efficient and Effective Communications and Responsiveness to Customer Needs

SIMES has made very great effort to provide effective communication with its customers and is very responsive to their needs and requests, inclusive of reports, research highlights and participation in DOE workshops, committees and panels.

NOTEWORTHY PRACTICES

- Active participation in DOE sponsored workshops and various initiatives–including Energy Frontier Research Centers and Mid-Scale Instrument Program
- Timely communication of research highlights

OPPORTUNITIES FOR IMPROVEMENT

More participation in BESAC meetings.

HEP

F ➤ Astrophysics

Objective 3.1 Provide Effective and Efficient Stewardship of Scientific Capabilities and Program Vision

It has been a major challenge to maintain morale in the non-Fermi part of the astrophysics program in the face of ongoing uncertainty about the nature of the program. The scientific capabilities reside largely in people. The management of the astrophysics program believes that it has provided stewardship of this resource.

NOTEWORTHY PRACTICES

We have hired excellent postdoctoral fellows, especially in support of the Fermi program.

OPPORTUNITIES FOR IMPROVEMENT

We need to achieve a better understanding of the DOE program.

Objective 3.2 Provide Effective and Efficient Science and Technology Project/Program Planning and Management

This year KIPAC members have participated in a DOE review of KIPAC, an overall PPA program review and a theory program review. Preparing for these three reviews has been a significant challenge and required KIPAC to develop its own strategic plan and collate supporting material. The reviews have helped clarify the directions that KIPAC scientists believe to be the most scientifically promising at this time and to open up a dialog with program managers within OHEP concerning their view of the future of the particle astrophysics and cosmology program.

NOTEWORTHY PRACTICES

We prepared a significant amount of documentary material for the various reviews.

OPPORTUNITIES FOR IMPROVEMENT

Using the experience gained to prepare more efficiently for the next review on non-accelerator physics.

Objective 3.3 Provide Efficient and Effective Communications and Responsiveness to Customer Needs

The major scientific customer at present is the Fermi-LAT collaboration. The ISOC has done an exemplary job, as discussed above, in satisfying this customer. A quite different, though no less important, customer is the general public and KIPAC has delivered many public lectures and participated in many educational endeavors that described recent scientific results.

NOTEWORTHY PRACTICES

Public lectures as discussed above.

OPPORTUNITIES FOR IMPROVEMENT

Changing the makeup of the ISOC as the mission evolves and the customer needs change. Continuing to deliver necessary computing services will be a challenge.

G ➤ *B*-Factory

Objective 3.1 Provide Effective and Efficient Stewardship of Scientific Capabilities and Program Vision

BABAR

The *BABAR* experiment plays a major role in setting the direction of the research in the field of high-energy physics, yielding results that significantly impact our understanding of the Standard Model and the direction of the search for physics beyond the Standard Model, as well as tests of the predictions of QCD. This was emphasized this year in the announcement of the Nobel Prize given jointly to Y. Nambu and to M. Kobayashi and T. Maskawa.

Numerous members of the *BABAR* collaboration are engaged in developing the next generation of accelerators and experiments required for precision studies of flavor physics, aiming for a nearly two orders of magnitude increase in integrated luminosity. A major focus of these studies has been the study of physics potential and feasibility of the proposed SuperB accelerator and experiment at the Frascati Laboratory in Italy. Important accelerator tests were carried out this year, with the direct involvement of physicists from the collaboration, to examine some of the fundamental ideas recently put forward to achieve a peak luminosity of $\sim 10^{36}$ /cm^2/s. The very encouraging results lead the community to expect that a decision to build the next SuperB complex will take place before the end of FY09. Because of this, it appears essential to take the necessary steps to guarantee that the main components of the *BABAR* detector can be reused for the SuperB detector. The D&D planning, which was developed this year in close coordination with the *BABAR* IFC, takes proper measures to preserve this appealing possibility.

H ➤ Elementary Particle Physics

Objective 3.2 Provide Effective and Efficient Science and Technology Project/Program Planning and

ATLAS at the LHC

During summer 2008, PPA and SLAC ATLAS worked to develop a plan for significant expansion of the existing ATLAS effort, including engagement in R&D for upgrades of the pixel, tracking, DAQ and trigger systems driven by plans for the Super LHC. The plan required exploration of existing and future opportunities and identification of leadership and expertise among existing EPP staff. The resulting white paper describes a plan for significant expansion of the SLAC effort from 15 FTEs in FY08 to more than 30 FTEs in FY09. Over and above ongoing commitments to the present detector, possible areas under consideration include a major effort on the Inserted B-Layer project, the Pixel System replacement for the stage 1 LHC upgrade, the development of a Western Data Analysis Facility and upgrades to the DAQ and HLT systems.

The focus of activities in FY09 will include:

- Continuing leadership and major contributions to the commissioning and initial operation of the Pixel and HLT Systems.
- Completion of the event overlay system and ongoing improvements to the muon simulation.
- Expansion of the Tier 2 center and development of a proposal for a Western Data Analysis Facility.
- Expansion of upgrade R&D activities directed towards the pixel and HLT systems.
- Discussions with U.S. ATLAS and OHEP are ongoing concerning implications and a detailed implementation plan for the white paper proposal.

J ➤ Scientific Computing

Objective 3.1 Provide Effective and Efficient Stewardship of Scientific Capabilities and Program Vision

The vision for SLAC scientific computing continues to emphasize the excitement of a laboratory whose experimental program has and will push hard against the limits of data-intensive scientific computing. This vision attracts and succeeds in retaining key staff in areas of leadership in core competency.

NOTEWORTHY PRACTICES

The vision of SLAC as a world leader in data-intensive scientific computing remains largely intact after the major budget reduction of FY08.

OPPORTUNITIES FOR IMPROVEMENT

A longer term vision is required to ensure that future SLAC science benefits from world-class scientific computing intellect in areas critical to the science mission.

Objective 3.2 Provide Effective and Efficient Science and Technology Project/Program Planning and Management

SLAC has processes to develop laboratory-wide plans for scientific computing facilities. These processes do not yet achieve the optimum level of input from and interaction with all segments of the SLAC science program.

NOTEWORTHY PRACTICES

The processes have been formalized with the creation of a Scientific Computing Sub Council in FY08.

OPPORTUNITIES FOR IMPROVEMENT

The formal processes must be exercised to increase the precision, including a full understanding of uncertainties, of planning for future scientific computing needs.

Objective 3.3 Provide Efficient and Effective Communications and Responsiveness to Customer Needs

SLAC scientific computing is very responsive to particle physics projects, but communication with other science activities needs improvement.

NOTEWORTHY PRACTICES

Active outreach to science beyond particle physics is underway.

OPPORTUNITIES FOR IMPROVEMENT

The Scientific Computing Sub Council should be used to guide and evaluate SCCS efforts to develop fully productive communication with all SLAC science.

Appendix A Acronyms and Abbreviations

2D	2-dimension
3D	3-dimension
AAAS	American Association for the Advancement of Science
AAC	Advanced Accelerator Concepts Workshop
AARD	Advanced Accelerator R&D
ABP	Advanced Beam Physics
ACD	Advanced Computations Department
ACTA	Advanced Telecom Computing Architecture
ALS	Advanced Light Source
AMO	Atomic, Molecular, and Optical physics
ANL	Argonne National Laboratory
APS	Advanced Photon Source (x-ray facility) at the Argonne National Laboratory
ARD	Accelerator Research Division
ARPES	Angle-Resolved PhotoEmission Spectroscopy
ASD	Accelerator Systems Division
ASTA	Accelerator Structure Test Area
ATCA	Advanced Telecom Computing Architecture
ATF2	Accelerator Test Facility
ATLAS	A Toroidal LHC ApparatuS (Particle physics experiment at CERN)
ATR	Advanced Microwave Technology Research
BBU	Beam Breakup
BDS	Beam Delivery System
BEPAC	Beyond Einstein Program Assessment Committee
BEPC-II	Beijing Electron Positron Collider upgrade
BER	Biological and Environmental Research
BERAC	Biological and Environmental Research Advisory Committee
BES	Basic Energy Sciences
BESAC	Basic Energy Sciences Advisory Committee
BICEP	Background Imaging of Cosmic Extragalactic Polarization
BL	Beam Line
BNL	Brookhaven National Laboratory
BPM	Beam Position Monitor
CAMD	Center for Advanced Microstructures and Devices
CCD	Charge Control Device or Charge-Coupled Device
CD	Conceptual Design
CDW	Charge Density Wave
CEBAF	Continuous Electron Beam Accelerator Facility
CEP	Carrier-Envelope-Phase
CERN	European Organization for Nuclear Research, Geneva, Switzerland
CETs	Centers for Enabling Technologies
CHESS	Cornell High Energy Synchrotron Source
CKM	Cabibbo-Kobayashi-Maskawa

CLIC	CERN Linear Collider
ComPASS	Community Petascale Project for Accelerator Science and Simulation
CP	Charge Parity
CPPM	Centre de Physique des Particules de Marseille
CSC	Cathode Strip Chamber
CTF3	CLIC Test Facility 3
CXI	Coherent X-ray Imaging
CY	Calendar Year
D&D	Disassembly and Disposal or Decommissioning and Disposal
DAQ	Data AcQuisition system
DESY	Deutsches Elektronen-SYnchrotron (Hamburg, Germany)
DFT	Density Functional Theory
DPF	Division of Particles and Fields
EFD	Experimental Facilities Division
EFRC	Energy Frontier Research Center
EGRET	Energetic Gamma Ray Experiment Telescope
EMI	Electromagnetic Interference
EMSL	Environmental Molecular Sciences Laboratory
EPAC	Experimental Program Advisory Committee
EPICS	Experimental Physics and Industrial Control System
ESA	End Station A
ESB	End Station B
ES&H	Environment, Safety and Health
ESRF	European Synchrotron Radiation Facility
EVMS	Earned Value Management System
EXO	Enriched Xenon Observatory
FACET	Facilities for Accelerator science and Experimental Test beams
FEL	Free-Electron Laser
Fermi	Fermi Gamma-Ray Space Telescope
FFTB	Final Focus Test Beam
FIP	Forum on International Physics
FLASH	Free-electron LASer in Hamburg (DESY)
FNAL	Fermi National Accelerator Laboratory
FPGA	Field Programmable Gate Array
FY	Fiscal Year
GC	General Contractor
GDE	Global Design Effort
GEANT4	A Standard Particle-Interaction Simulation Toolkit
GLAST	Gamma-ray Large Area Space Telescope
GSFC	Goddard Space Flight Center
GTL	Gun Test Laboratory
HEPAP	High Energy Physics Advisory Panel
HGRF	High-gradient RF

HHG	High Harmonic Generation
HLT	High Level Trigger
HOM	High-Order-Mode
ICHEP	International Conference on High Energy Physics
IFC	International Finance Committee
INFN	Istituto Nazionale di Fisica Nucleare (Italian National Institute for Nuclear Physics, Frascati)
IN2P3	Institut National de Physique Nucleaire et de Physique des Particules
ILC	International Linear Collider
IMCA-CAT	Industrial Macromolecular Crystallography Association Collaborative Access Team
INCITE	Innovative and Novel Computational Impact on Theory and Experiment
ISOC	Instrument Science Operations Center
ISR	Initial State Radiation
ITAPS	Interoperable Technologies for Advanced Petascale Simulations
JCSG	Joint Center for Structural Genomics
JDEM	Joint Dark Energy Mission
KEK	Koo Energy Ken. The High Energy Accelerator Research Organization, Tsukuba, Japan.
KEKB	KEK B-factory
KIPAC	Kavli Institute for Particle Astrophysics and Cosmology
KMD	Klystron/Microwave Department
LAL	Laboratoire de L'Acc'el'rateur Lineare, Orsay
LARP	LHC Accelerator Research Program
LAT	Large Array Telescope
LBNL	Lawrence Berkeley National Laboratory
LCLS	Linac Coherent Light Source
LCWS	Linear Collider Workshop
LDRD	Laboratory Directed Research and Development
LHC	Large Hadron Collider
LHC-AR	LHC-Accelerator Research Group
LLNL	Lawrence Livermore National Laboratory
LN	Liquid Nitrogen
LOI	Letter of Intent
LSST	Large Synoptic Survey Telescope
LUSI	LCLS Ultrafast Science Instruments
MAC	Machine Advisory Committee
MEIS	Molecular Environmental and Interface Science
MIE	Major Item of Equipment
MMS	Minimum Maintenance State
MSSM	Minimum Supersymmetric Standard Model
NCCS	National Center for Computational Sciences
NCRR	National Center for Research Resources
NE-CAT	Northeastern Collaborative Access Team at the APS
NERSC	National Energy Research Scientific Computing Center
NIBIB	National Institute of Biomedical Imaging and Bioengineering

NIGMS	NIH Institute for General Medical Sciences
NIH	National Institutes of Health
NIM	Nuclear Instruments and Methods
NIST	National Institute of Standards and Technology
NLCTA	Next Linear Collider Test Accelerator
NMSSM	Next-to-Minimal Supersymmetric Standard Model
NRC	Nuclear Regulator Commission
NSF	National Science Foundation
NSLS	National Synchrotron Light Source
NSLS-II	National Synchrotron Light Source II
NSRRC	National Synchrotron Radiation Research Center
OCPA	Overseas Chinese Physics Association
OECM	Office of Engineering and Construction Management
OHEP	DOE Office of High Energy Physics
ORNL	Oak Ridge National Laboratory
PAC	Particle Accelerator Conference
PEMP	Performance Evaluation and Measurement Plan
PEP-II	Upgraded SLAC PEP electron-positron collider
PEP-X	Synchrotron storage ring project at SLAC utilizing PEP-II
PES	PhotoEmission Spectroscopy
Pic3P	new 3D parallel finite-element particle-in-cell code
PLS	Pohang Light Source
PPS	Particle and Particle Astrophysics Directorate, SLAC
PRL	Physics Review Letters
PRP	Proposal Review Panel
PRST-AB	Physical Review Special Topics - Accelerators and Beams
PS	Photon Science Directorate, SLAC
PSI	Paul Sherrer Institut
PULSE	Photon Ultrafast Laser Science and Engineering center
PWFA	Plasma-based Wakefield Acceleration
QCD	Quantum Chromo-Dynamics
QUaD	QUEST at DASI (ground based cosmic microwave background polarization experiment)
R&D	Research and Development
RDR	Reference Design Report
RF	Radio Frequency
RHIC	Relativistic Heavy Ion Collider, BNL
RIXS	Resonant Inelastic X-ray Scattering
RPC	Resistive Plate Chamber
S&T	Science and Technology
SAC	Scientific Advisory Committee
SAM	Stanford Auto-Mounting System
SAXS	small-angle X-ray scattering
SBC-CAT	Structural Biology Center Collaborative Access Team

SBIR	Small Business Innovation Research
SC	Office of Science
SCCS	Scientific Computing and Computing Services
SciDAC	Scientific Discovery through Advanced Computing
SciDB	An Open Source Data Management System for Data-Intensive Scientific Analytics
SESAME	Synchrotron light for Experimental Science and Applications in the Middle East
SEY	Secondary Electron Yield
SFA	Science Focus Area
SGX-CAT	Structural Biology Center Collaborative Access Team
SiD	Silicon Detector concept for the ILC
SIMES	Stanford Institute for Materials and Energy Science
SISGR	Single-Investigator and Small-Group Research
SLAC	SLAC National Accelerator Laboratory
SLM	Synchrotron Light Monitor
SM	Standard Model
SMB	Structural and Molecular Biology
SNAP	SuperNova Acceleration Probe/Program
SNS	Spallation Neutron Source, ORNL
SPC	Scientific Policy Committee
SPEAR	Stanford Positron Electron Accelerating Ring
SPEAR3	Upgrade of the old SPEAR ring, synchrotron radiation source at SSRL
SPPS	Super antiProton Proton Synchrotron
SPS	Super Proton Synchrotron at CERN
SRC	Synchrotron Radiation Center, Madison, Wisconsin
SSRL	Stanford Synchrotron Radiation Lightsource
SSRLUOEC	SSRL User's Organization Executive Committee
SUSY	SUperSymmetrY
SU	Stanford University
T3P	parallel time-domain finite element code
TFT	Thin Film Transistors
THz	Terahertz
TIFR	Tata Institute of Fundamental Research
TJNAF	Thomas Jefferson Lab National Accelerator Facility
TOPS	Towards Optimal Petascale Simulations
TPC	Time Projection Chamber
TPS	Taiwan Photon Source
Track3P	parallel time-domain finite element code
TXM	Transmission X-ray Microscopy
TXRF	Total Reflection X-ray Fluorescence
UHV	Ultra-high Vacuum
USPAS	U.S. Particle Accelerator School
WIPP	Waste Isolation Pilot Plant
XAS	X-ray absorption spectroscopy

XES	soft X-ray emission spectroscopy
XFEL	X-ray Free Electron Laser
XLDB	Extremely Large Database
XPP	X-ray Pump Probe
XPS	X-ray Photoelectron Spectroscopy
XRF	X-ray Fluorescence
XRS	X-ray Resonant spectroscopy

Publications Appendix

This appendix is located on line at
http://www-group.slac.stanford.edu/oa/selfevaluation/2008/fy08pubsappendix.pdf