Message from the Director

–Keith Hodgson

The past 12 months have been remarkable in many respects. There were two events that really marked the beginning of the fiscal year. Artie Bienenstock accepted a position as Associate Director for Science at the Office of Science and Technology Policy in Washington, and with his departure I became Acting Director of SSRL (being notified of this act by FAX while on holiday in Hawaii). Almost simultaneously, the DOE Basic Energy Sciences Advisory Committee (BESAC) released the findings and recommendations of the Birgeneau/Shen Panel, which evaluated the four DOE synchrotron user facilities. During this time we were beginning final preparations for our 1998 user run which turned out to be in many ways our most successful ever. Let me elaborate on a few of these events and accomplishments and refer you to articles found in this newsletter for further details of these and other happenings during the past year.

(continued on pg. 2)

Dear SSRL Users,

This year’s user run began on an extremely positive note following the BESAC review panel’s favorable comments concerning the future of synchrotron radiation facilities and, in particular, the future of SSRL. However, as Keith Hodgson pointed out during the 1997 Users’ Conference, there are many challenging tasks in the near future that will require attention in order for SSRL to maintain a high level of productivity and quality user beamtime. Your Users’ Organization Executive Committee has been actively working on your behalf with the SSRL Laboratory Management Group (LMG) to address many of these issues such as: 1) the expanding user base and availability of beamtime, 2) the development of new beamlines and capabilities, 3) maintaining a strong support staff, 4) state-of-the-art computational and web-based tools, and 5) diagnosing and improving beam stability.

This year marks the 25th anniversary of SSRL, and reveals that SSRL has come a long way in growing into a dedicated SR user facility. Although I was not around in the early days during parasitic operation mode, I had my share of stalk anticipation moments in 1990 during the commissioning run of the new dedicated injector. Thus, I assume everyone can appreciate and applaud the significance of the fact that during the first week of July 1998, SSRL achieved 100% delivery of beam to users for the first time ever. In addition, the overall delivery rate for this year’s run was 96%. These are impressive accomplishments and are a significant source of our scientific productivity.

The origins of this success will not go unnoticed. The SSRLUO Executive Committee, acting on a suggestion by Joe Wong of LLNL, is initiating an annual award to recognize important technical or scientific accomplishments. All SSRL support staff and users are eligible to receive the award. The award has been named in honor of Farrel Lytle. As you may know, Farrel has done a tremendous service to the SSRL user community over the past two decades in a variety of ways, particularly in bringing and introducing new users to synchrotron radiation experimentation, educating, collaborating and assisting users in all aspects of XAFS spectroscopy. Since SSRL is known for its excellence in user support, we are pleased to recognize Farrel as the first recipient of the new annual award during the 25th annual Users’ Conference celebration.

The future is incredibly bright, with no pun intended. We are now seeing the operation of new beamlines in Sector 9, and looking forward to an additional arsenal of wiggler-based lines in Sector 11. As we head into the time where SPEAR3 will become a reality, it will be important from a user standpoint to insure that the transition is as smooth as possible and potential delays in our continued scientific progress are minimized. In the end, we will have a state-of-the-art 3rd generation SR user facility which will be well worth the investment of time and money. On this note, the FY’98 run ended with an appended period of accelerator physics tests during which, a beam current of 200 mA was successfully stored for 5 hours!

–Pat Allen, LLNL
Chair, SSRLUO-EC
The Birgeneau/Shen Report provided a strong endorsement of the general user approach to facility operations that we have evolved over the years. Continued effective operation of SSRL with adjustments for inflation was included in the highest priority recommendation of the Panel's Report. The Report also provided strong endorsement for going forward with SPEAR3, this project being only one of two major upgrades endorsed by the Panel. Of particular note relevant to our user community were the observations made by the Chair, Dr. Robert Birgeneau, during his presentation to the BESAC. Dr. Birgeneau noted that SSRL's users were remarkably pleased with SSRL and the service it provides its user community. As noted in the article from Pat Allen in his capacity as Chair of the SSRLUO, we must not be complacent and need to redouble our efforts to find ways to improve the quality of beam time provided to our users and to extend our science into new dimensions. Also contained in the Birgeneau/Shen Report was a strong recommendation for investment in R&D for 4th generation sources. We hope to be able to take advantage of such an opportunity as the R&D program for LCLS progresses toward enabling construction to begin in a few years.

The 1998 run and beam provided to users was outstanding in many aspects. The scheduled beam was delivered to users 96% of the time, a record for us. We were able to accommodate an increased number of users on new beam lines (most notably BL9-1 (protein crystallography) and BL2-1 (powder diffraction) while improving the efficiency and capabilities of several other beam lines through detector and optics upgrades. Through the efforts of SSRLUO and the SSRL staff, we were able to continue our effective end-of-run survey system and were pleased that more than 60% of the users rated their overall experience in the highest category. The written comments from these user surveys have helped guide improvements in many areas. It has indeed been extremely beneficial to have such an excellent working relationship with the users and the SSRLUO, and we look forward to finding even better ways to work together in the future. An organization like ours reflects directly the dedication and efforts of all the individuals. I would like to recognize the SSRL Staff for their untiring efforts to continue to improve the facility, and hence the quality of service and beam we provide to the users.

Significant progress has been made in planning for SPEAR3. In January, Tom Elioff joined SSRL as an Assistant Director for the SPEAR3 Project. Working closely with Bob Hettel, Richard Boyce, Jeff Corbett and the many other members of the SSRL and SLAC staff involved in this project, a conceptual design was completed during the first half of 1998. The conceptual design report (CDR) was delivered to a DOE review committee, chaired by Daniel Lehman, prior to the committee's visit to SSRL in late July. The Lehman Committee carried out an in-depth technical, cost and schedule review of the SPEAR3 project. The outcome was overwhelmingly positive and a real tribute to the efforts and success of the SPEAR3 team. This summer, the old Mark III detector was removed from the "west pit" in order to make way or the SPEAR3 upgrade. R&D activities for the project during FY 1999 are currently being defined with the goal of a full project start at the beginning of FY 2000. Less then 3 years after that, SPEAR3 can become a reality, bringing significant benefits to all of our user community.

We must also continue to strive to look towards the future. New steps in this direction taken during 1998 include full operation of two stations on Beamline 9, adding new capabilities for dilute x-ray absorption spectroscopy and for protein crystallography. There was also significant progress toward the completion of the molecular environmental science Beamline 11. Following commissioning next spring and summer, this new beamline will offer the user community unique capabilities for studying environmentally hazardous and sensitive samples with state-of-the-art x-ray absorption spectroscopy tools. Also during 1998, we were able to develop a collaboration to fund a new side station on Beamline 11 for protein crystallography. BL11-1 will be a partnership between Stanford University, The Scripps Research Institute and SSRL and will provide researchers from these institutions and SSRL general users access to the most intense protein crystallography beamline at SSRL. Another step in defining future directions came with addition of Dr. Martin Greven as a joint faculty member with SSRL and the Department of Applied Physics. Martin will be developing a research program and new experimental capabilities in the area of magnetic materials. LCLS is also making progress, noting particularly the publication of a seminal design study early in 1998 and the VISA experiment, which is being planned for later this year, to demonstrate SASE with saturation in the visible energy region.

Let me close by urging all of you, our user community, to make your views known and work with the SSRLUO and us to make SSRL an even better facility to serve your needs and push the scientific frontiers. By working together we can develop new capabilities and see both SPEAR3 and the next generation of synchrotron source become a reality. I look forward to exciting times as we move forward beyond a truly remarkable 25 years and into the next century of synchrotron-based science.
FY’98 User Experimental Run

~Suzanne Barrett

Members of the User Administration office were on their toes from November through July administering to the needs of the 752 users who arrived at SSRL during the 1997/1998 run. This number represents only a portion of the SSRL active user community of more than 1500, as evidenced by user demand exceeding available beamtime by 44% on all beamlines, when combined, and over 82% on insertion device beamlines in fiscal year 1998. User traveled from near and far to take advantage of our 26 experimental stations and our record breaking 96% beam delivery rate. We hosted users from over 17 countries and 204 institutions. Our US users traveled from over 38 states across the country but as expected are heavily West Coast oriented.

You might be surprised to learn that the SSRLUO-Executive Committee turned the tables on the user community and gave the SSRL support staff an opportunity to voice their opinion regarding you – the SSRL users! The staff survey addressed how prepared you were to conduct your experiments, the reasonableness of your support expectations and whether the proposal spokesperson takes adequate responsibility for his/her experiment. The results were consistently positive. There were, however, some consistent themes among the staff in terms of user support issues – users unaware of hardware needs, last minute set-up or hardware changes, inadequate planning, and poor housekeeping. On the complimented users on the extensive two-way communication and feedback they receive and the direct user-staff relationships. There seems to be ample evidence of mutual

‘You continued to applaud our efforts throughout the 1997/1998 run with over 88% of all users reporting an “excellent” to “very good” overall experience at SSRL.’

Every onsite user has the opportunity to voice their appreciation or concern regarding their experience at SSRL through the End of Run Summary Form. You continued to applaud our efforts throughout the 1997/1998 run with over 88% of all users reporting an “excellent” to “very good” overall experience at SSRL. Eighty percent of our users rated the quality of beam as “excellent” to “very good”. 

(continued on pg. 4)
FY’98 Experimental Run
(continued from pg. 3)

respect between our support staff and the SSRL user community.

I would like to take a moment to thank Dave McKay of Stanford University for chairing the SSRLUO-EC throughout FY’98. Dave is handing over the reigns of the SSRLUO-EC to Pat Allen of LLNL. With six of the ten members of the committee rolling off this year Pat will be leading a new and hopefully enthusiastic Executive Committee throughout FY’99. You can reach Pat or any other member of the SSRLUO-EC through the SSRLUO web page at http://www-ssrl.slac.stanford.edu/SSRLUO.html

Distribution of the 315 Proposals Receiving Beam in FY98:

34% Life Science
31% Material Science
14% Environmental Science
 6% Chemical Science
15% Other

Upcoming Meetings and Workshops

November 18, 1998
Protein Crystallography Workshop: Xenon Derivatization of Protein Crystals Using the MSC Cryo-Xe-Siter Flash Cooling Device

January 12–14, 1999
LCLS Workshop

October 11–12, 1999
SSRL 26th Annual Users’ Conference

October 13–15, 1999
SRI’99

User Administration Points of Contact

Beam Time Request Forms
X-ray & VUV
Protein Crystallography/MAD
Michelle Steger
Daphne Mitchell

End of Run Summary Forms
Diana Viera

Hazard Forms
Michelle Steger

Institutional User Agreements
Michelle Steger

Proposal Submittal Reviews
X-ray & VUV
Protein Crystallography/MAD
Michelle Steger
Daphne Mitchell

Safety/No Bars Talks
Diana Viera

Scheduling
X-ray & VUV
Protein Crystallography/MAD
Suzanne Barrett
Marjorie St. Pierre
Daphne Mitchell
Michelle Steger

User Accounts
User Dosimeters
Michelle Steger
Diana Viera

User Support Forms
Michelle Steger

Email: first.last@ssrl.slac.stanford.edu

SSRL Publications Acknowledgment

ssrl submits several annual reports to the Department of Energy and the National Institutes of Health which require up-to-date publications listings. These publications lists are extremely important in presenting our scientific achievements and productivity, and thus funding case to these agencies. Users and staff are asked to submit two copies of each publication or thesis based, fully or partially, on work at ssrl to the attention of Lisa Dunn. A reference submittal form is available for users and staff to provide reference information in advance of the actual preprint distribution at the following url: http://biosg1.slac.stanford.edu/admin/form_publications.html

For both staff and users the correct acknowledgment, which must appear in the publication is:

➤ Work done (partially) at ssrl which is operated by the Department of Energy, Office of Basic Energy Sciences.

All biology users and materials and environmental EXAFS users should add the following:

➤ The ssrl Biotechnology Program is supported by the National Institutes of Health, National Center for Research Resources, Biomedical Technology Program, and by the Department of Energy, Office of Biological and Environmental Research.
SSRL Faculty News

Martin Greven joined the faculty of Stanford University, in joint affiliation with the Applied Physics Department and SSRL in January of 1998. He was born and raised in Germany, and received his Vordiplom in Physics and Mathematics in 1988 from Heidelberg University. In 1995, he received his Ph.D. in Physics from the Massachusetts Institute of Technology, where he stayed as a Post Doctoral Associate until December 1997. Martin's research interests are in materials physics with an emphasis on advanced single crystal growth, x-ray scattering, and neutron scattering of high-temperature superconductors and materials which exhibit low-dimensional magnetism. Martin is spearheading a project to build a superconducting magnet facility at SSRL for completion in early 1999 (for more details see pg. 8).

Gordon E. Brown, Jr. became Chair of the SSRL Faculty effective September 1, 1998. The Kirby Professor of Earth Sciences since 1991, Gordon originally came to the Stanford Geology Department in 1973 from Princeton University. He went on to serve as Chair of the Geology Department from 1986–1992 and Co-director of the Stanford Center for Materials Research from 1987–1990. He has also held Visiting Professor appointments at Sandia National Laboratory and the Laboratoire Mineralogie-Cristallographie, Université de Paris 6 & 7. Gordon has been a member of the SSRL Faculty since its inception in 1992 and has headed the development of the molecular environmental sciences program at SSRL.

Herman Winick officially retired from the SSRL Faculty as of June 1998. However, he has been called back to work a 50% schedule until June 1999. When asked how he is enjoying his new status he responded, “It doesn’t feel any different”. With roots back to 1973 when SSRL was known as the Stanford Synchrotron Radiation Project (SSRP) it is not difficult to believe that the 100% plus effort habit is a hard one to break. Indeed, Herman’s talent for enthusiastically involving others in his activities prompted one staff member to coin the term “Winicked”.

During his years at the lab Herman served as SSRL’s Deputy Director from 1974–1995 and as an Assistant Director from 1996 to the present. Herman has been honored with several awards including the Alexander von Humboldt Senior Scientist Award in 1986, DOE Materials Sciences Research Competition winner, Solid State Physics Category in 1987 (for the introduction of wiggler magnets into storage rings to produce very intense synchrotron radiation) and the US Particle Accelerator School Prize for Achievement in Accelerator Physics Technology in 1995.

Junior Faculty Position to be Added to SSRL Faculty

A search committee is currently reviewing the applications received for a tenure-track junior faculty position in the field of structural molecular biology. The new faculty member will be associated with the core mission of SSRL’s Structural Molecular Biology group to provide support in data collection hardware and software to visiting users and will be expected to develop, enhance, and support the scientific and technological focus in the area of macromolecular crystallography.

Faculty Retreat

--Gordon E. Brown, Jr.

The SSRL Faculty and Staff held an off-site retreat on April 14, 1998 at the Foggarty Conference Center on Skyline Drive in Woodside, CA. The main purpose of the retreat, which Seb Doniach and I organized with considerable help from Suzanne Barrett, was strategic planning in the wake of the Birgeneau/Shen Report. The 1997 review of the four DOE Synchrotron Radiation Sources by the BESAC Synchrotron Panel pointed out two main strengths of SSRL: (1) the high level of user support and general satisfaction of SSRL users, and (2) the strong involvement of Stanford faculty in developing scientific programs at SSRL, particularly in the areas of structural molecular biology (continued on pg. 6)
Faculty Retreat
(continued from pg. 5)

and biotechnology, condensed matter physics, molecular environmental science, polymer science, and TXRF analysis of contaminants on semiconductors. One conclusion drawn from the retreat is that SSRL cannot afford to rest on past successes. Instead, we must develop even higher levels of user support as well as new scientific programs that involve both Stanford faculty and other users. The SPEAR3 upgrade was another topic of discussion by faculty and staff, as was the Linear Coherent Light Source project. Both of these projects are very important for the future vitality of SSRL as a premier user facility. The retreat ended with a dinner and an after dinner speech by Herman Winick who reviewed the history of SSRL from its inception to the present and beyond. It has been over 25 years since SSRL provided its first user light, and surprisingly, Herman looks about the same as he did back in 1973.

SSRL Visitors

Kai and Anna-Britta Siegbahn visited SSRL in January to get an update on current research. Siegbahn is the editor of Nuclear Instruments and Methods in Research and in that capacity monitors activity in various scientific fields. He also works with the ESCA laser lab in Uppsala and was the winner of the 1981 Nobel Prize in physics (shared with Schawlow and Bloembergen).

Their host, Herman Winick, prepared an ambitious agenda in which the

"SSRL has great potential since you have the linac...if you hurry you can be first."

–Kai Siegbahn on the LCLS

Siegbahns met with John Arthur and Roman Tatchyn for discussions on X-ray optics in general and a more in-depth review of the Linac Coherent Light Source (LCLS). The Siegbahns also met with Z.-X. Shen and Ingolf Lindau to discuss the latest in science with soft x-rays.

Kai Siegbahn was fully aware of the DESY activities in Hamburg and plans for linac-based free-electron lasers, but he remarked that “SSRL has great potential since you have the linac...if you hurry you can be first.”

Several other distinguished scientists have visited SSRL during the past year on either a long-term or short-term basis.

Klaus Wille, from the Institute of Accelerator Physics and Synchrotron Radiation at the University of Dortmund, visited from February-August to help out with the SPEAR3 design effort. His contribution was significant to the overall success of the recent Lehman Review.

Ki Bong Lee, a Beamline Department Director at the Pohang University of Science and Technology with research interests in the field of x-ray magnetic circular dichroism (XMCD) spent much of his sabbatical visiting SSRL from February-August of this year.

Ruy Hanazaki do Amaral Farias, from the Laboratorio Nacional de Luz Sincrotrón (LNLS) in Brazil, also arrived in February 1998 to spend a year at SSRL. He is being hosted by Helmut Wiedemann and his research is primarily focused on the activities at the SUNSHINE Facility on Campus.

Claudio Pellegrini, a physicist at UCLA, spent a six-month sabbatical at SSRL last year to work on the LCLS Design Study Report and returned this summer for a month-long visit to continue with his close collaboration with SSRL, BNL and LANL in preparation for the Visible-Infrared SASE Amplifier (VISA) free electron laser experiment that is expected to be performed at Brookhaven this fall.

Ingolf Lindau has spent the past year at Stanford and SSRL while on sabbatical from his position as Director of the MAX-Lab at the University of Lund.

SSRL has also hosted visits by Canadian and Australian delegations proposing to build synchrotron radiation facilities in their respective countries. The scientists and government officials visited SSRL and other facilities to learn more about the latest applications of synchrotron radiation. They were also interested in our plans to rebuild the SPEAR ring to meet third generation source standards.

Several other visitors are expected to arrive this fall including Holger Mannweiler, a graduate student from the Institut für Kernphysik at Mainz University who is coming to SSRL to work on his Master’s thesis; Jonathan Hunter Dunn, a postdoctoral research assistant from Uppsala University, who will be using the EPU to study magnetic thin films with magnetic circular dichroism; and Shogo Sakanaka, from KEK, who will be collaborating on the LCLS project during his three-month stay at SSRL.
Summer Shutdown Projects

Mark III Removal. The Mark III detector, which yielded many years of service for High Energy Physics Experiments, was removed from SPEAR. Its removal marks the final transition for SPEAR from a HEP machine to a dedicated Synchrotron Radiation Facility. With the detector out of the West Pit of SPEAR, SSRL can begin the process of completing the tunnel shielding and reconfiguration of this area away from the old HEP lattice. Its removal also allows for construction of new beamline alcoves and building expansion in the future. The removal process of the 350-ton detector was a collaborative effort, with SSRL and SLAC clearing away the shielding blocks and focusing magnets and a contract awarded to a vendor to remove the detector for scrap metal. After the detector was removed, the lattice magnets and vacuum system were restored and operationally tested for the upcoming run cycle.

Bldg. 118 Air Conditioning. The SPEAR power supply building was fitted with an air conditioning system during the downtime in an effort to extend the lifetime of the power supplies and their circuitry. The temperature often reaches the 100 degree F range during the hot months which leads to small chillers or fans being used to cool a few of the critical power supplies. This project, lead by the SSRL Facilities group, included a 15-ton air handling system, duct work which has a built in smoke detecting system, thermostatic control, and cooled by the existing chilled water system at SPEAR. The results of the project will lead to more stable air temperature in the building and therefore more stable power supplies which in turn yield a more stable beam in the storage ring.

M₀ Mirror Replacements on BLs 6-2 and 10-2. Beamline 6-2 saw its M₀ mirror tank completely removed from the beamline and transported up to the LOS Vacuum Shop. The water-cooled mask which protects the upstream end of the mirror from normal incidence synchrotron radiation developed a leak during the 96–97 run. This leak was discovered when someone observed one of the recesses underneath a shielding block through which electrical cables were run was completely filled with low conductivity water. It was found that the leak was vanishingly small if we cooled this mask with domestic water (recirculated) because of the greatly reduced water pressure. During the FY’97 shutdown a decision was made to postpone its repair until we had a new mirror to install at the same time. Accordingly, the mirror was ordered and installed during the FY’98 shutdown and the water leak was repaired as well. Beamline 10-2 also had its M₀ mirror replaced but as there were no water leaks involved, the replacement was done in situ. In addition, the vacuum group pulled the Be window mask for remeasurement of its alignment fiducials. There has been a long-standing mystery as to why the high-energy cutoff of the monochromator didn’t behave as expected. It turned out that the alignment fiducials of this mask were off by 0.028”. This should explain why (220) crystals could not reach energies above 28 keV.

Beamline 7 Bypass. In order to make room for the new experimental superconducting magnet station on BL7-2, a new walkway has been constructed along the outside wall of Bldg. 120 in the Beamline 7 area.

LCW Re-route. The LCW piping used to be supported 9’ above grade spanning across the access to the western end of Bldg. 131 and the West Pit. A 40’ long x 4’ wide x 3’ deep trench was dug to bury one 8” supply and one 8” return pipe, eliminating the overhead clearance for vehicles. Access through this area will

Brian Choi, head of SSRL Facilities.
Summer Shutdown Projects
(continued from pg. 7)
mostly be limited to government vehicles and for unloading user equipment.

Bldg. 131 Fire Alarm Upgrade. The Bldg. 131 fire alarm was upgraded to a new addressable system manufactured by Pyrotronics to be in compliance with SLAC fire protection requirements. New pull stations, strobes, horns, smoke detectors, HVAC duct detectors and an MXLR panel either replaced the existing ones or were installed for the first time in the building.

New SSRL Staff Trailer. Specifications for the installation of a modular office trailer were being prepared to meet the needs of new SSRL staff hires. The trailer will be located in the northwest corner of the Bldg. 120 parking lot, directly across from the SSRL engineer trailer complex inside the radiation fenced-off research area. The trailer will be approximately 48’ x 60’ and will contain 15 permanent partition offices, two handicap-access restrooms, light kitchen facilities and a conference room.

Bldgs. 120 & 131 Roof Repair. A roofing subcontractor was hired by SLAC Facilities to locate and repair the roof leaks in Bldgs. 120 and 131 that have plagued staff and users for the past several years.

5-Phase Motor Project. Each time the beam emittance in SPEAR is reduced, the resolution possible on each beamline is improved, driving the requirement to increase the number of steps over a given range of crystal rotation. Due to the large dynamic range of the monochromators, the speed at which the monochromators can change energies must also be increased. The x-ray beamline monochromator controls on 12 beamlines were upgraded during the summer of 1998.

The upgrade consists of replacement of 4-phase crystal rotation motors and drivers with 5-phase motors and drivers, and the implementation of a low-noise motor pulse transmission interface, important in the sensitive data acquisition environment of the experiment areas.

The 5-phase motors have higher torque ratings than the 4-phase motors and are run in a mode of 100,000 steps per degree as opposed to 4,000 steps per degree. The maximum step rate has increased from 5 kHz to 20 kHz. The increased number of steps, combined with larger motor bearings, provides smoother operation. Also, because of the higher torque rating and the increased number of steps per degree, the right-angle gear reducer, a potential source of mechanical errors, has been eliminated.

BEAMLINE PROJECTS

Superconducting Magnet Facility
—Martin Greven

During the past decade, transition metal and rare earth compounds have been at the forefront of materials research and condensed matter physics. In particular, the discoveries of high-temperature superconductivity and of colossal magnetoresistance have created much excitement and a wealth of research due to their implications for both fundamental science and technological applications. Other recent discoveries, such as the first inorganic spin-Peierls material, the spin-ladders, and the borocarbide superconductors also have had a significant impact. In all these and in many related systems magnetism, or the vicinity to a magnetic phase, plays a fundamental role. The magnetism of these “strongly correlated electron systems” is generally intimately coupled with their electronic and structural properties, and slight compositional changes or variations of external parameters often lead to new phases. Consequently, the presence of a magnetic field can have dramatic effects on these properties, and may lead to fundamentally new phases. For example, a large enough magnetic field will introduce vortices into a superconductor and eventually destroy the superconductivity. In the colossal magnetoresistance materials, the application of a magnetic field can switch the systems from an insulating to a conducting state, or from one crystal structure to another.

Synchrotron x-ray scattering has proven to be an increasingly important tool in both materials science and condensed matter physics. For example, it is possible to obtain bulk structural information with a momentum resolution exceeding that achievable with neutron diffraction techniques by an order of magnitude, consequently allowing to probe larger length scales. The advent of high-intensity x-rays at synchrotron sources (continued on pg. 9)
Superconducting Magnet Facility  
(continued from pg. 8)

has also led to the important new research area of magnetic x-ray scattering; large resonant enhancements in the magnetic scattering cross section have been discovered for photon energies tuned to atomic absorption edges.

In order to elucidate further insight on the diverse magnetic and magneto-elastic properties of transition metal and rare earth compounds, a new high-field magnet facility is currently being implemented at Beamline 7. This nearly unique facility will allow work at magnetic fields of up to 13 T and over the very wide temperature range 0.3 K < T < 400 K. The magnet, which is currently being built by Oxford Instruments, has a split-pair design with room for a He-4 variable temperature insert, which allows access to temperatures as low as 1.5 K. An additional He-3 insert will extend the accessible temperature range to 0.3 K. Due to the split-pair design of the magnet, experiments will be confined to the horizontal scattering plane. Construction of a new hutch that will house the magnet is presently underway directly behind station 7-2. The new magnet facility is expected to be available in early 1999.

The LIGA Line  
– Michael Rowen

A new white light x-ray branch line is being constructed on Beamline 3 for a dedicated LIGA (Lithographie, Galvanoformung und Abformung, i.e. lithography, electroplating and molding) station. LIGA is used to describe a number of related processes for fabricating mini and micro scale parts in metal or plastic. One of the defining steps is lithography, in which a pattern of the part is recorded in a resist. The most common method is to use x-rays to expose thick resists, for which synchrotron radiation is ideally suited. The new branch line, BL3-1, will be on the SPEAR side of Jumbo, BL3-3. It will use the 3.4 mrad of bend magnet radiation made available by the decommissioning of the Grasshopper and Saya-Namioka monochromators. The station will be equivalent to BL2-2, with no mirrors, only beryllium windows and filters to isolate the branch line from SPEAR vacuum and helium drift space from the experiments. The radiation fan will be 8 cm wide at a dedicated scanner in the hutch. This project is being done at SSRL in conjunction with Sandia-Livermore and JPL.

Beamline Optics Modernization Project  
– Tom Rabedeau

SSRL has embarked upon a major effort to modernize existing beamline optics. Beamline 7-2 was one of the first beamlines to benefit from this program with the installation of a new mirror in December. The new mirror system is designed to improve the beamline focus stability, increase the mirror photon collection efficiency, and optimize the beamline energy cutoff for the current usage of the beamline.

These goals were accomplished by replacing the existing ~0.6 m, Pt coated, uncooled, quartz mirror with a 1.2 m, Rh coated, side clamp cooled, single crystal Si mirror. By using a longer mirror, the collection efficiency of the mirror was increased even though the cutoff energy of the mirror was raised to ~14 keV to facilitate more reciprocal space access. Replacing the Pt coating with Rh coating eliminated the troubling Pt L-edges from the beamline spectra. Selection of Si as the mirror body both improved the thermal response of the mirror and vastly reduced the mirror susceptibility to radiation damage. Adding side clamp cooling has contributed enormously to the beamline stability. The focus stability with the old mirror was typically ~200 µm rms over the course of several days. With the new cooled mirror this focus stability has improved to ~20 µm rms with most of the residual motion resulting from SPEAR source motion. Residual SPEAR contributions to focus instability, however, can be reduced by using a mirror pitch feedback system which is currently in testing. The feedback system uses the focus position determined by a split ion chamber located in the experimental hutch to adjust a piezo driven fine adjust of the mirror pitch. In tests, this feedback system has demonstrated 3.7 µm rms stability and has compensated >100 µm SPEAR fill shifts to less than 4 µm. We anticipate installation of an operational mirror feedback system on Beamline 7-2 during the 1999 run.

Next up in this mirror modernization program are the M mirrors on Beamlines 6-2 and 10-2. Like Beamline 7-2, the replacement mirrors will be Rh coated, side clamp cooled, 1.2 m single crystal Si. The 10-2 mirror will retain the existing 21 keV cutoff, while the 6-2 mirror cutoff will be reduced to 15 keV to improve power filtering for the 6-2 monochromator. It is anticipated that these new mirror systems will incorporate pitch feedback systems similar to that employed on Beamline 7-2. The 6-2 and 10-2 Si mirrors are currently in procurement. Since the mirror procurement leads the installation by at least a year, the existing mirrors were replaced during the 1998 shutdown with comparable Pt coated quartz mirrors as discussed on page 7 in this newsletter.
Normal Incidence Monochromator

–Changyoung Kim and Michael Rowen

As reported last year, the construction phase on the new low energy (10–40 eV) Normal Incidence Monochromator (NIM) branch line to Beamline 5 was completed in 1997 and first light was brought through the entire system in late July. Commissioning interspersed with user running on BL5-2 and BL5-3, continued with the start of the run in November. The tasks during the remainder of 1997 were integration of the control system, and characterizing optical elements. The work on implementing the software and hardware interface was continued in 1998. The M₁ mirror, which is of profiled float glass, does not produce the desired figure. Ripples in it produce multiple images of the source at the entrance slit. These cannot be brought into coincidence. In 1998 the platinum coated glass horizontal refocusing mirror was replaced on delivery of a silicon mirror with higher reflectivity.

Further optimization and testing of the beamline has been performed since the high-resolution scintia photoelectron spectrometer was moved on line. The gas cell test on the He absorption edge shows the energy resolution is better than 1 meV, which gives a resolving power of better than 20000. This is even better than the original target resolution of 3 meV. Combined with the scintia end station, overall resolution of 7.2 meV was achieved from the gold Fermi edge, which is mostly due to the analyzer resolution. However, the intensity is not yet up to the expected level. There are a few problems, most notably the grating. The monochromator has a grating with sinusoidal profile which, compared to a blazed angle grating, has close to 3 times poorer throughput while showing comparable energy resolution. Blazed angle gratings have been procured and are expected to be delivered before this November. Work on other parts of the beamline to improve the intensity is in progress.
Beamline 11-2
– Tom Rabedeau, John Bargar and Gordon E. Brown, Jr.

Beamline 11-2 saw significant progress during the 1998 run though it also suffered a disappointing setback when the wiggler delivery was delayed until the winter of 1998. It seems that the process used to apply the anti-corrosion coating to the magnet blocks actually initiated corrosion, resulting in failure of the magnet block glue joints during magnet assembly. Testing alternative anti-corrosion processes coupled with magnet block remanufacturing delayed the wiggler delivery until January of 1998. Despite these difficulties, the Danfysik A/S design and construction team ultimately delivered a magnet that far exceeded the performance specifications with a peak field of 2.0 T (5% over specification) and a very square field profile. In parallel with the wiggler fabrication effort at Danfysik A/S, an SSRL team designed and constructed a stainless steel vacuum chamber to conduct the SPEAR electron beam through the wiggler. Since the chamber dimensions control the magnet pole gap and hence the magnetic field attainable by the insertion device, the vacuum chamber team exercised considerable care resulting in the straightest insertion device chamber yet produced at SSRL (0.008” total deviation from ideal dimensions over the 2.3 meter chamber length). The vacuum chamber and wiggler were installed into the SPEAR ring during the summer 1998 shutdown.

Above: Jenny Hostetler and Abelino Anaya assembling BL11 components.

Below: Ted Gathright and James Peck (standing) discussing the BL11 comb mask assembly.

The design and fabrication of the beam transport and optics hardware occupied much of the attention of the SSRL Beamline Development Group during the 1998 run. While most of the front-end components were designed, fabricated, and installed in 1997, the few remaining front-end components were installed during the 1998 shutdown. The long lead M₀ and M₁ mirrors were ordered early in calendar 1998. Though the mirror optics were not scheduled for delivery until late fall 1998, the M₀ and M₁ mirror mover/bender systems were designed and fabricated well in advance of this scheduled delivery of the mirror optics. This proved fortuitous as SESO delivered the M₀ mirrors (one for 11-1 and one for 11-2) two months early with figure and roughness performance substantially better than the specification. The assembly of the M₀ mirror system will commence once the flurry of vacuum group activities associated with the summer shutdown calms down. At present we project installation of the M₀ mirror system towards the end of the fall. In addition to the mirror systems, a number of beam transport masks, slits, filters, windows, and supporting hardware were designed during the 1998 run. As of this writing, much of this hardware is in fabrication or undergoing final assembly. At this juncture, the 11-2 monochromator is the most significant design challenge remaining. Given the likelihood of the SPEAR3 upgrade and the high power density associated with the 26-pole wiggler, it was decided to employ liquid nitrogen crystal cooling technology for this monochromator. LN₂ monochromators are new to

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Beamline 11-2

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SSRL, but such technology has proved itself in several years of operations at the ESRF and more recently at the APS. As of this writing, the crystal design is well along and the LN$_2$ pump and heat exchanger are in procurement. An engineering and design team is currently adapting the Beamline 9 monochromator design for application as an LN$_2$ monochromator on BL11-2. The current schedule calls for installation of this monochromator in late March or early April of 1999, with commissioning to start late in the following summer.

Progress has also been made in the conceptual design of the actinide containment and storage facility though detailed design will not commence for several months. Present plans call for retaining the actinide trailer and constructing a more modestly sized sample storage facility adjacent to the 11-2 hatch. While a full sized actinide handling facility at the 11-2 hatch would prove most convenient, the associated loss of floor space in the vicinity of the 11-1 and 11-2 experimental stations proved incompatible with the layout and operation of the beamlines. This compromise solution permits storage of samples near the 11-2 hutch, but also facilitates unloading, packing, and storage of bulkier sample materials to somewhat more remote and consequently less valuable space.

Beyond the current Beamline 11 construction project, we have plans to construct a micro-beam XAS facility based on Kirkpatrick-Baez focusing mirrors. We estimate these optics should deliver about 10$^{10}$ photons/sec into a 5x2 μm focused spot (more flux should be available for larger spot sizes). In comparison, BL4 stations currently (using the SPEAR2 lattice) provide about 10$^{11}$ photons/sec in an unfocussed 20x2 mm beam. Hence, the micro-beam XAS facility will enable users to measure element and oxidation state distributions, edges, and even XAFS spectra from samples on micron length scales.

The New Dedicated Powder Diffractometer at SSRL

–Apurva Mehta

During 1997, we commissioned a new experimental station (Beamline 2-1) with dedicated instrumentation for x-ray powder diffraction. In the past, four circle diffractometers at beamlines such as 7-2 and 10-2 were used for powder diffraction experiments. It took considerable time to setup and align a four-circle diffractometer for high resolution powder experiments. By building a dedicated powder diffractometer, we were able to build in some standard instrumentation, such as an analyzer, that most powder experimenters want. We were also able to simplify the alignment procedure by fixing the chi and the phi motion of the diffractometer; designing specialized sample stages for powder and polycrystalline samples, and fabricating appropriate alignment tools. The ease of use of the dedicated powder diffractometer has not only drawn users from oversubscribed beamlines such as 10-2 and 7-2, but has also attracted many new users to SSRL.

Powder diffractometers are found on campuses of all major academic and research institutes. Most laboratory instruments utilize x-ray radiation emitted from a metallic target when bombarded with thermionically generated electrons. Though the x-ray flux density at a synchrotron source is several times higher, most synchrotron powder diffraction systems, including the new instrument on Beamline 2-1, are designed to take advantage of other unique features of the synchrotron source such as low divergence. While they are not faster than a common laboratory instrument, they are, however, capable of performing tasks that are impossible on sealed tube instruments. Experimenters on Beamline 2-1 over the past year have come to utilize these unique features of a synchrotron powder diffractometer. Some of these unique features are described below.

The angular resolution (q space resolution) of a powder diffractometer is predominantly governed by the divergence (angular and spectral) of the incident beam and the diffracted beam (receiving) slit aperture. The angular divergence of the incident beam at a synchrotron diffractometer is 2–3 orders of magnitude lower than for a common laboratory instrument. It is thus possible to achieve ultra-high angular resolution on a synchrotron powder diffractometer by utilizing a very narrow receiving slit. A perfect crystal in the analyzer geometry acts as a very narrow receiving slit. A Si (111) analyzer is the standard configuration on the powder diffractometer on Beamline 2-1.

The intensity of a diffracted beam from a powder sample is several orders of magnitude lower than the intensity of the incident beam. Thus, the tail of the incident beam is a major contributor to the background in a powder pattern. The low divergence and high intensity of the incident synchrotron beam yields a powder diffraction pattern with significantly better signal-to-background.

The figure on page 13 shows a comparison of data collected on identical samples on one of the state-of-the-art sealed-tube powder diffractometers on the campus of Stanford University and a high-resolution synchrotron powder diffractometer. Not only does the synchrotron diffractometer fully resolve the doubling that the Stanford instrument sees as a singlet, it also picks out the weak Bragg peak (see the inset) that is lost in the background of the sealed-tube spectrum. These features of a high resolution synchrotron diffractometer makes it ideally suited for investigating subtly broken crystal symmetry or detection of very small

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Powder Diffraction Results

The powder diffraction station at BL2-1 was used in a project to study U(VI) speciation in chemical reactive barriers designed to remediate U(VI) contamination in groundwaters at field locations in the Western US. A major hypothesis of this study is that precipitation is a dominant control on U(VI) solubility in the reactive barriers. Synchrotron powder diffraction proved to be highly useful because our samples contain multiple crystalline phases and are too dilute to be analyzed using conventional XRD. The XRD data are also highly complementary to EXAFS and SEM-EDAX measurements. The synthesis of information from these techniques will make it possible to ascertain the relative roles of precipitation and sorptive processes in the barriers. The results of this study, yet in progress, will be highly useful to estimating the viability, useful life, and hence costs, of chemical reactive barriers.

Powder Diffractometer

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amounts of a minority phases. Several of the experimenters who came to Beamline 2-1 last year came specifically to take advantage of the higher resolution and signal-to-background ratio of the synchrotron powder diffractometer.

Sealed tube x-ray sources are line or point sources only few tens of centimeters from the sample. Thus, the incident beam on the sample is highly divergent. To achieve reasonable angular resolution most of these instruments are designed on parafocus geometry. In this configuration, the angle of incidence must be the same as the angle of reflection (i.e., symmetric Bragg condition). A synchrotron source point is usually several meters from a diffractometer, e.g., the diffractometer on Beamline 2-1 is 21 m from the source, and is forward scattering. Therefore, the x-rays incident on a synchrotron diffractometer are almost parallel. Thus, synchrotron diffractometers are designed using parallel beam geometry. There are many advantages of parallel-beam geometry. For example, aberrations due to sample width and displacements are completely eliminated in parallel-beam geometry by using a crystal analyzer.

The other important advantage of parallel-beam geometry is that there is no loss of angular resolution when the angle of incidence is not the same as the angle of reflection. This feature of a synchrotron diffractometer could be utilized to selectively investigate a thin surface layer by fixing the angle of incidence such that the radiation penetrates to only a predetermined depth into the sample.

Energy of the x-ray photons at most synchrotron sources, unlike sealed tube x-ray sources, can be precisely and continuously tuned over a wide range. By tuning of the x-ray energy to an absorption edge of an element, one can alter the real and imaginary parts of the scattering cross-section via resonance effects. There are many applications of resonance scattering. Beamline 2-1 can access the absorption edges of first row transition metal and rare-earth metals. One of the experiments on Beamline 2-1 used the resonance scattering effect to look for ordering of two different oxidation states of iron in a crystal.

In most academic and research institutes a powder diffractometer is used as a phase “finger printing” tool during the course of sample synthesis. A synchrotron powder diffractometer can be used similarly. However, because of its other unique capabilities, some of which I have described above, 1997–98 users of the diffractometer on Beamline 2-1 either collected data for very accurate determination of crystal structures or performed experiments that were otherwise impossible on sealed-tube-based instruments.
The TXRF Project on Beamline 6-2

–Sean Brennan and Piero Pianetta

Over the past several years, we have gone from a development phase in which we were trying to prove the usefulness of synchrotron radiation based Total X-ray Reflection Fluorescence (TXRF) to one in which industrial users are performing industrially meaningful experiments. The most intense development activity took place in 1995 and 1996. By the end of 1996, we brought our detection limits to the level of $3^8$ atoms/cm$^2$ for transition elements, which is over an order of magnitude better than TXRF using conventional sources. This was achieved by source developments (high throughput, low background multilayer monochromator optics) and by detector improvements. The detector developments deserve additional comment. The original detector (a Si(Li) solid state detector) showed background parasitic peaks of Fe, Ni and Cu at levels which interfered with the signals of interest. These three elements are the primary elements that we are interested in analyzing at high sensitivity. These signals were produced by internal detector components that were struck by the radiation scattered from the silicon wafer. We found that, by replacing the internal components of the detector with high purity materials which did not contain any of the elements of interest, we were able to completely eliminate the parasitic peaks and achieve true $3^8$ atom/cm$^2$ detection limits. Also, by the end of 1996, we added a clean-room inside the hutch and constructed a new measurement system that allowed us to map both 150 and 200 mm diameter wafers.

By mid-1997, the new measurement system was commissioned with the capabilities of fully automated measurements of a single wafer and semi-automatic wafer loading. We showed that this system added no additional metal contamination to test wafers and we brought in users beyond those who were working on the system development. Since that time we have had a 7–8 user groups per run which gave each group approximately two days of beamtime. These user groups are predominantly from the semiconductor industry, but are also from analytical laboratories and universities. The lead industrial associate has been Hewlett-Packard, with Stephen Laderman and Alice Fischer-Colbrie of Hewlett-Packard Laboratories actively involved in the development of the technique. Other semiconductor manufacturers include AMD, Applied Materials, ARACOR, DEC, Intel, IBM, Lucent, Motorola, National Semiconductor and Texas Instruments. The analytical labs are Balazs Analytical Lab and Charles Evans and Associates. The university groups have been Atom institute of Vienna, Austria and Stanford University. These groups have brought a wide range of samples for study, including intentionally contaminated wafers used as standards for other wafer measurement techniques, samples where other techniques such as surface photo-voltage have predicted significant metal contamination, and representatives of each group’s “cleanest” wafer, to see whether our TXRF technique can see contamination that their own equipment cannot. Other samples include wafers covered with metals (Cu, W) or wafers which are difficult to measure using the photon energy typically available with a conventional TXRF unit. These would include arsenic implants, or bromine contamination. For a copper-covered wafer, we shift the incident energy below the Cu K-edge, which minimizes the Cu fluorescence and allows us to look for contaminants up to Ni within the film.

The goals for the next year are to complete the automation of the wafer-handling system and to replace the counting electronics with digital electronics, which should allow us to increase our throughput by reducing the data collection dead time. The new mirror on 6-2 should improve the focused intensity of the beam.
The MES user community continued to experience strong growth last year. A total of about 1,900 8-hour shifts were scheduled for MES experiments in the 1997–1998 season, an increase of about 150% compared to the previous year. Beamline 4-3 was the most heavily utilized beamline at SSRL, having about 415 shifts scheduled for MES experiments (equivalent to about 67% of the available time on 4-3 during 97/98). Examples of MES usage at other beamlines, as percentages of available time per station, include 62% at 4-1, 35% at 4-2, 27% at 6-2, and 14% at 7-2. In total, about 2.7 full-time equivalent beam stations (an FTE beam station is equivalent to the amount of time available on an average beam station during the entire season) were used for hard x-ray MES measurements in the past season. This demand level exceeds projections made at the 1997 MES Workshop on Synchrotron Radiation Facilities (SSRL, Jan. 17, 1997) by an entire FTE beam station (1.7 were projected), indicating the rate of growth has been greater than anticipated. The diversity of MES experiments on SSRL beamlines is striking. As a community, we investigated contaminant (cation and anion) uptake and fixation by plants, microbes, soils, airborne particles, fuels, and synthetic chelating agents, the environmental chemistry and stability of actinides and nuclear materials, the fundamental chemistry of high level nuclear waste separations processes and waste forms, in-situ remediation technologies for radionuclides and metal ions, the structures and chemistry of organic environmental materials, and the fundamental structures and bonding of solid-aqueous solution interfaces.

The past season witnessed several important developments for MES researchers at SSRL, most notably in the areas of instrumentation, user support, and beamline development. Detectors top the list. During fall of 1997, an order was placed for a 30-element Ge array detector from Canberra, optimized for use in the 5 to 25 keV region. We anticipate delivery of this system in October. Instead of traditional analog SCA (or TCA) electronics, the detector will be equipped with a DXP digital signal processing system from XIA, Inc. This system, which was funded by the DOE Scientific Facilities Initiative (SFI) through Stanford University, should provide substantially greater signal throughput than traditional SCA systems, will be completely computer controlled, and offers the capability to acquire and process the entire energy spectrum incident on the detector. Full utilization of this latter feature will require considerable data acquisition and processing software development, which is currently undertaken by members of the SSRL Biotechnology group as part of SSRL’s continued detector developments for XAS. When operational, this detector should yield much improved distinction between overlapped signals, and hence greater S/N, than is currently possible with existing Canberra detectors at SSRL. In addition to this new hard x-ray detector, an order was recently placed for two solid state detectors optimized for use in the soft x-ray region (approximately 250 to 4,000 eV). One of the detectors will be a 10-element Ge array, and the second a single-element Ge detector having an active area of 100 mm$^2$ active area.

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MES Developments
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Both detectors will be equipped with DXP signal processors. Each will be windowless, enclosed in bellows for use at vacuum beamlines, and mounted on a motorized slide to facilitate positioning. These detectors, which were also purchased with DOE-SFI funding, should substantially enhance the capability to perform soft x-ray fluorescence yield measurements on wet samples at SSRL.

During the upcoming season, funding permitted, SSRL plans to hire new staff members for the purpose of maintaining our current level of user support as new facilities and instrumentation come on line. Specifically, the new staff will help operate and maintain Beamline 11-2, provide ES&H support for experiments at 11-2, support new detectors, and provide increased support for MES users at other SSRL beamlines. A significant development in the area of user support accomplished in the past season was the construction of an MES web site, http://www-ssrl.slac.stanford.edu/MES/, which contains useful information for both new and advanced users. Please see the description of this site in the accompanying article in this newsletter. One feature of the web pages that requires your help is the EXAFS spectral data base. If you have good XAFS spectra of environmentally relevant samples and are willing to share these spectra with the molecular environmental science community, please contact Dr. John Bargar about adding these spectra to the SSRL-MES XAFS spectra data base.

Summer Science Students Construct MES Web Pages

John Bargar

During summer 1998, several new Web page information resources were developed for users at SSRL. The pages, located at http://www-ssrl.slac.stanford.edu/MES/, were constructed by undergraduate students Gabriel Peterson (UC Berkeley) and Trinh Van (Reed College) while participating in the SLAC Summer Internships in Science and Engineering (SISE) program. The central focus of Gabe and Trinh’s project was to learn about instrumentation and methods in x-ray absorption spectroscopy. Using this knowledge, they assembled several documents for publication on the Web, which provide much useful information for users at SSRL. Perhaps the most notable of these are the XAFS Model Compound Library and the Guide to XAFS Measurements at SSRL. The XAFS model compound library (pictured above) is a repository of published reference compound spectra measured at SSRL, which users may access and download for use in data analysis and interpretation. This resource is based solely upon spectra donated from the user community, and to grow this resource we encourage users to donate spectra. Submission of spectra is quick and easy using the Web page - just click on the “Submit Spectrum” button and follow the instructions. The Guide to XAFS Measurements document was designed to be useful for planning and performing measurements. Accordingly, it contains concise descriptions of subjects ranging from beamline alignment, to estimating intrinsic spectrometer resolution, to choosing filters for fluorescence yield measurements. The guide contains numerous tables of physical constants necessary for calculations described within. Feedback has been positive, and we encourage users to send us comments. The overall project was initiated and directed by SSRL staff scientist John Bargar. We would like to thank the staff of SSRL, particularly Lisa Dunn, Mike Soltis, Peter Kuhn, and Michael Rowen, for their help and donation of resources used in this endeavor.
During the 24th Annual SSRL Users’ Meeting in October 1997, 25 scientists attended a full day workshop on ultra-high resolution data collection and xenon-derivatization. The workshop was divided into lectures and hands-on training. Over the past few years, both techniques (xenon derivatization and ultra-high resolution) have been developed and streamlined by SSRL staff. The workshop provided the first hands-on advice for the planning and execution of these new experiments. The proceedings are published on the www at http://biog1.slac.stanford.edu/research/workshop97/. The lectures were given by SSRL scientists Mike Soltis, Paul Ellis, and Peter Kuhn, who were supported by Aina Cohen (SSRL), Pamela Williams and Natalie Kresge (The Scripps Research Institute) during the practical sessions held at Beamline 9-1. Experimenters learned how to prepare xenon derivatives and calculate Patterson maps for use in the multiple isomorphous replacement method of structure determination. Instruction on the experimental setup for ultra-high resolution data collection and a tutorial for data reduction were provided. Since the successful workshop, a number of new xenon-derivatized structures and ultra-high resolution structures have been published.

In July of 1998, a workshop was hosted by SSRL on the crystallographic phase determination software, SHARP, developed by Eric de la Fortelle and Gerard Bricogne (Cambridge, UK). One of the authors, Eric de la Fortelle, presented the main lecture, and provided an excellent introduction into the principles of SHARP as well as insights into the installation procedure. A number of ‘real-life’ examples were provided along with some of the details for the usage of the advanced, web-based user interface and the interpretation of the results. A lively group of over 25 scientists from various research groups along the West Coast engaged in questions and discussions on various aspects of crystallographic structure determination with regard to experimental procedures and different phasing software packages. This also provided an excellent forum to discuss future perspectives on computing capabilities at the crystallographic beamlines. The unified opinion was that it would be very advantageous to extend the available and supported software packages to include phasing programs such as SHARP and SOLVE. The SSRL staff is currently working on a preliminary solution for the start of the 1999 run. Because of the overwhelming interest expressed by the community in this workshop, we are planning to organize a follow-up workshop in the near future.

The Scripps Research Institute (TSRI), Stanford University and SSRL have entered into a Participating Research Team (PRT) to construct and operate a new crystallography beamline (11-1), signing the Memorandum of Understanding (MOU) in April 1998. Bill Weis (Stanford University), Ian Wilson (TSRI) and Peter Kuhn (SSRL) have been appointed liaison scientists for their respective institutions. This arrangement is the first step towards a closer scientific interaction between the three institutions in the area of structural molecular biology. The construction and operation of the beamline will be fully integrated within SSRL and 1/3 of the beam time will be available to the general user community. The construction of Beamline 11 is currently underway and first light is expected in late 1999. In addition, as part of this agreement, an enhanced MAR345 detector was procured to replace the existing MAR300 detector on Beamline 7-1, which should be available at the beginning of the 1999 run.

Collaboratory. The Biotechnology group at SSRL, in collaboration with the macromolecular Crystallography Facility at CHESS (MacCHESS) and the San Diego Supercomputing Center (SDSC), is pleased to announce the establishment of a collaboratory for protein crystallography. Funded for four years by the NIH NCCR, the goal is to design and implement “Virtual Beamlines” within the framework of a “Center without Walls”. The collaboratory will develop a road map leading from the protein crystal to the molecular structure, in which scientists are linked with other scientists, crystallographic data, and crystallographic software. The collaboratory will provide an environment in which our user groups will have high-speed, virtual access to national resources for their structural molecular biology research.
New Developments and Recent Enhancements to the Protein Crystallographic Facilities

–Protein Crystallography Group

First Light in Beamline 9-2

After heroic efforts and much help by members of the SSRL Beamline Development Group, Vacuum Group, Operations Group and the Biotechnology Group, focused light was first brought into the new structural biology end station 9-2 in mid-June. After further refinement of the alignment and stability of the x-ray optics, a preliminary test data set from the protein myoglobin was collected on this beamline using a Quantum-4 CCD x-ray detector in the final days of the run.

Experimental Apparatus Used on Beamline 9-2

As mentioned in the last SSRL Users Newsletter, we have purchased an Area Detector Systems Corp. 2x2 matrix Quantum-4 CCD detector and a Huber Kappa-geometry goniometer for use on beamline 9-2. During the past year, we have designed and built a prototype computer-controlled positioning stage for both the detector and goniometer. This stage is extremely stable and allows the CCD detector to be accurately positioned over extended vertical and horizontal translations in a plane normal to the x-ray beam. This allows for maximum flexibility in data collection. The CCD can also be rotated about a horizontal axis so that it can face the sample at any vertical position (two-theta motion). Furthermore, both the goniometer and the detector can independently be moved over an extended distance along the beam path, so that large unit cells can be resolved. The stage is also designed to accommodate a MAR345 imaging plate detector system if required for certain experiments and as a backup detector.

The Kappa geometry goniometer will allow us the flexibility to collect data about any axis, and provides a large unobstructed volume around the sample for an array of support instrumentation. Since it is equipped with computer controlled X, Y and Z sample translations, we plan to design automated sample alignment software, incorporating image analysis of optical sample alignment views, over the next year or two.

Additional Advanced Detectors Purchased

A second ADSC Quantum-4 CCD detector was received in the spring of this year and has been placed in service on our bending magnet MAD station (Beamline 1-5). This detector has performed well and has now replaced the Fuji BAS2000 off-line imaging plate system previously used there. Last year, as mentioned in the last Newsletter, we received a large fast MAR-Research MAR345 imaging plate data collection system for our monochromatic wiggler Beamline 9-1. This detector has performed very well and has produced a vast amount of data over the last year. Because of our overall satisfaction with the system, we have placed orders for two additional MAR345 systems. One system is funded by The Scripps Research Institute to replace the MAR300 on Beamline 7-1 and the other is funded by DOE-OBER to act as a spare or an alternative detector for all of our crystallography beamlines.

Enhancements to Our Beamline Computer Systems

During the past year great progress has been made towards upgrading our beamline control, and data processing computer systems to state-of-the-art systems. Our goal has been to have a relatively standard array of computer systems on each of our protein crystallography beamlines that permit extremely rapid data processing and the graphical display of results during the users beam time, to assess the quality of data. Much of this goal has already been realized, and hopefully the remaining systems will be upgraded during the coming year. The current model for each beamline is to have a Digital AlphaStation running (continued on pg. 19)
**Protein Crystallography Developments and Enhancements**  
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Open VMS for beamline control, a Digital AlphaStation running Digital UNIX for data collection, a separate Digital UNIX workstation for data processing, and a dual processor SGI Octane running IRIX for graphics display and data backup. A central server has been provided to handle user accounts and home directories. A high-bandwidth network backbone is now in full operation across the facility providing the required speed to the outside Internet for transfer of diffraction data to home institutions.

**Standard Software for Protein Crystallography Beamline Control**

During the past year a sophisticated and flexible beamline control Graphical User Interface (GUI) has been designed and written in Tcl/Tk which can be run under UNIX, OpenVMS and Win32 platforms. A Distributed Control System (DCS), which supports an arbitrary number of computers providing low-level hardware control at a single beamline, and simultaneous user interface clients running anywhere on the network, has also been written. The DCS is interfaced to the Instrument Control System (ICS) written by Martin George in the SSRL Biotechnology group, which is being adopted to control most of the beamline hardware on SSRL beamlines. When the protein crystallography GUI and DCS software has been completed, and all our beamlines are equipped with state-of-the-art computer systems, it will be adopted as a standard throughout all of our protein crystallography beamlines. The GUI and DCS software has been written by Tim McPhillips in our group.

**Some Research Highlights from Data Collected on Beamlines 7-1 and 9-1**

Beamlines 7-1 and 9-1 produced again a wealth of science over a very wide spectrum of structural molecular biology, from very large and difficult complexes to probing atomic detail at ultra-high resolution. Over 30 new structures have been solved this year. Some of the recent Science and Nature publications include: The Wilson Group of The Scripps Research Institute published 2 new structures; a T cell receptor complexed with an antigen and an antibody inhibitor complex. The Hol Group (University of Washington) also published 2 papers, one of which was in collaboration with SSRL staff scientist, Peter Kuhn. Based on the structure of human topoisomerase I complexed with DNA, a mechanism for the way the anti-cancer drug target modifies DNA was proposed. The Choe Group of the Salk Institute published the crystal structure of the Shaker potassium channel, a membrane protein. Also reported was the structure of an early photocycle intermediate in photoactive yellow protein at 0.85 Å resolution. This ultra-high resolution work was made possible by a collaboration between the Getzoff Group of The Scripps Research Institute and S. Michael Soltis and Peter Kuhn of SSRL.

**Beamline 1-5 Highlights**

The past year has been an extremely successful one for Beamline 1-5 in large part due to the presence of the new Quantum-4 CCD detector. Users report that data sets can be collected with the CCD more than twice as rapidly as with the manual imaging plate system previously used on BL1-5. Software to automatically change the wavelengths for MAD data collection was implemented near the end of the run further automating data collection. There were 36 beamtime periods allocated on BL1-5 of which 26 were for MAD crystallography, with Se-methionine continuing its predominance as the preferred anomalous scatterer. Several groups had electron-density maps from their MAD data before they left SSRL. Reports of solved structures have continued to come in as users have processed their data at home. In addition to the MAD work, BL1-5 was also used to collect data from several very large protein-nucleic acid complexes at wavelengths that optimized the contribution of heavy atom derivatives.

In June, data sets were collected from insulin crystals grown on earth and on the space shuttle to test the effect of microgravity on crystal growth. The beamline was temporarily placed in unfocussed mode and the data were collected in very narrow frames (0.001 deg) to allow for a detailed
Protein Crystallography Developments and Enhancements (continued from pg. 19)

assessment of the reflection profiles. The data are also being used by ADSC to develop fine slicing software for general use in macromolecular crystallography.

News

As part of a large Singapore-USA Memorandum of Understanding on high-speed network connections between the two countries, SSRL scientists and scientists from the University of Singapore have entered into a collaboratory. The goal is to develop and incorporate a system that allows for remote data collection and analysis of diffraction data.

Biological Small Angle X-ray Scattering/Diffraction on Beamline 4-2

--Hiro Tsuruta

We received a Hamamatsu CCD x-ray detector system in July. This system, designed primarily for non-crystalline diffraction, consists of a 6” x-ray image intensifier with a Be window, a lens coupler and a full-frame rate cooled CCD camera. The detector system gives negligible amount of dark current, and its readout noise corresponds to less than 0.1 x-ray photon in the slow read-out mode. The fast scan mode (7 Hz without binning and 50 Hz with 4x4 binning) is effective in time-resolved studies. We confirmed the system characteristics in July. The high sensitivity of the system and the ability to circularly average an isometric diffraction pattern shorten exposure time drastically, making time-resolved studies in short time-scales possible. Our standard linear gas chamber detector system has received a PC-based signal processing system, developed at the EMBL Hamburg outstation. The new system is user-friendly, and adds the capability of rejecting coincident events which would increase the background level at high-count rates. The identical system has been adopted by several other SAXS/D facilities worldwide, providing better data format compatibility with other facilities.

A new stopped-flow apparatus for time-resolved solution x-ray scattering has been commissioned. This apparatus is equipped with optical beam paths for monitoring local conformational changes of a protein via UV/visible absorption or fluorescence simultaneously with time-resolved solution x-ray scattering. Another new mixing device has been developed by D. Segel (Stanford) and J. Hofrichter (NIH), aimed at conducting time-resolved solution scattering experiments at very early time scales. Two solutions are pumped at a high flow rate continuously into a special mixing nozzle, and exiting as a jet. One can observe different time points in the kinetics by hitting different points on the jet with the x-ray beam. It is possible to focus the x-ray beam on a point ~10 ms from the mixing point and obtain satisfactory counting statistics with a 10-minute exposure.

We are assembling a new goniostat equipped with a color video microscope system for low-angle single crystal diffraction. An automated Image Plate exchanger is being designed. It has been decided that the Fuji BAS2000 scanner will be moved from BL1-5AD to BL4-2. These will speed up low-angle single crystal diffraction studies on BL4-2.

Beam time statistics and future: Approximately 60% of the available user beam time on BL4-2 in FY’98 was used for studies of biological macromolecular systems using small angle x-ray scattering/diffraction techniques. We are discussing ways of increasing SAXS/D beam time on BL4-2 substantially over the next few years, including the possibility of dedicating 4-2 to SAXS/D in the future. We plan on holding two additional workshops on biological SAXS/D early in 1999. The workshops will focus on practical aspects of solution scattering and low-angle single crystal diffraction data collection, respectively. Interested parties are encouraged to contact Hiro Tsuruta to take part in the experiments performed.

At last, it should be mentioned that the BL1-4 small angle scattering facility for soft condensed matter physics is also being upgraded, an effort led by John Pople and Alice Gast (SSRL & Chemical Engineering, Stanford). The Olive CCD detector will receive an upgrade for better maintainability and user friendliness. During the shutdown an extension was added to the I-4 experimental hutch to allow longer sample-to-detector distances.
**Beamline 9-3 Commissioning**

*Ingrid Pickering and Paola deCecco*

During the 1998 run the structural molecular biology XAS Beamline 9-3 was commissioned, and in the last part of the run was successfully used for several experiments. The source for Beamline 9 is a 16-pole 2 T hybrid wiggler, and the x-ray optics consist of a vertically collimating mirror, a double crystal Si(220) pin-post cooled monochromator, and a 1.2 m re-focusing mirror. This configuration provides high flux with both excellent energy resolution and good focus. Moreover, the Rh coated optics eliminate the Pt L edges from the beamline spectra. Figure A shows a typical focus at 9 keV.

A dedicated Canberra 30-element Ge detector was received in the early spring and thoroughly tested. It is being used with analog electronics (AMP/TCA modules) and the integrated system was commissioned with the SSRL-developed control software running on the beamline data acquisition Digital AlphaStation. The beamline will be routinely run with a custom-built motorized rail and liquid helium cryostat. Initial experiments included both standard XAS measurements and, in the last part of the run, micro-XAS. Figure B shows a comparison of data from a sample run on Beamline 7-3 and 9-3. There is a marked improvement in signal-to-noise in the 9-3 data; while some of this (about a factor of 1.5) is due to the use of the 30-element detector on 9-3 and a 13-element detector on 7-3, the superior qualities of 9-3 are clearly apparent.

**Chemically Specific XAS Imaging Initiative at SSRL**

*Ingrid Pickering and Graham George*

XAS imaging is a technique which uses small x-ray beams, typically of 100 µm or less, in conjunction with raster scanning of the sample to provide spatially resolved XAS spectroscopic information. During the 1997–1998 experimental run the high photon fluxes of Beamlines 9-3 and 6-2 were exploited for XAS imaging experiments at SSRL. These first experiments by Ingrid Pickering (SSRL), Graham George (SSRL), David Salt (Northern Arizona University) and Roger Prince (Exxon) were designed to help understand the biochemistry of uptake and storage of selenium by the hyperaccumulating plant *Astragalus bisulcatus* (also called locoweed by cattle farmers). The experiments employed 13-element (6-2) and 30-element (9-3) Ge fluorescence detectors. Data of samples containing ~1 mM selenium were obtained with good signal to noise at 100 µm resolution, and data with adequate signal to noise were obtained at the highest resolution of 20 µm. Age-related partitioning between oxidized and reduced selenium species in the plant tissues was clearly observed. These results not only provide important information on the mechanism of selenium hyperaccumulation, but are very encouraging for future XAS imaging experiments at SSRL.
Beam Instrumentation Workshop '98

The Beam Instrumentation Workshop (BIW’98) was hosted by SSRL and SLAC and took place on site from May 4–7, 1998. This was the eighth Beam Instrumentation Workshop in a series, first convened in 1989 at Brookhaven National Laboratory. These Workshops address the design principles and engineering issues of beam diagnostic and control instrumentation for charged particle accelerators and beam transport lines. The Workshop is intended to promote a forum in which practitioners can exchange ideas and review instrumentation designs. It also serves as an introduction to relevant topics for engineers and scientists with the aid of tutorial sessions. The Workshop Organizing Committee is charged with selecting the recipient of the Faraday Cup Award for innovative achievement in the field of accelerator beam instrumentation, donated by Bergoz, L.C. of Crozet, France, and presenting it to the winner during the Workshop.

The Workshop had 149 registered participants, of which about a quarter were from Europe, Great Britain and Asia. The Workshop welcome was given by Ewan Paterson, head of the SLAC Technical Division, on behalf of Burton Richter, the Director of SLAC. The Workshop included 4 tutorials, 5 invited talks (including the Faraday Cup Award talk), 14 contributed talks, and 44 poster displays. Seven discussion sessions were held on topics selected by the registrants from a larger list. A banquet was held on Wednesday evening at the Golden Gate Yacht Club, where participants were treated to a rare glimpse of the sun as it set beyond the Bridge during a week of wind, rain, and even tornadoes, provided by the infamous El Niño. A tour of SLAC facilities, including the Linac Klystron Gallery, the PEP-II tunnel, the BaBar Detector, the SLC Detector Hall, the NLC Test Accelerator, and SSRL, was given at the end of the Workshop. The Proceedings of BIW’98 will be published by the AIP Press and can be found on the World Wide Web at the following address:


BIW’98 Program (partial)

**Tutorial Talks:**
- Beam Diagnostics and Applications
- Polarimeters and Their Applications - Electrons
- Protons
- Cavity BPMs
- Camera Technology and Image Processing

**Invited Talks:**
- Instrumentation and Diagnostics for PEP-II
- High-Average-Power Proton Beam-Profile Measurements
- Real-Time Orbit Feedback at the APS
- RHIC Instrumentation
- A Cryogenic Current Comparator for the Absolute Measurement of na Beams (Faraday Cup Award)

**Discussion Sessions:**
- Challenges in Beam Profiling
- High Performance Beam Position Monitors
- 4th Generation Light Source Instrumentation

**Beam Loss Monitors**
- Calibration Methods
- Commercial rf Technology & Beam Instrumentation

From left: Julian Bergoz, Stephen Smith and Robert Hettel presenting the Faraday Cup Award to Andrews Peters of (GSI DARMSTADT).
The SPEAR3 Upgrade Project design team received high marks and a few timely recommendations at the close-out of the DOE Review of SPEAR3 technical design, cost and project management plans held at SLAC on July 28–30, 1998. The Review Committee, chaired by Daniel Lehman from the DOE Energy Resources Division (ER), was comprised of Ray Schwarz and Mike Osinski from the DOE/ER together with technical consultants John Galayda (APS/ANL), David Harding (Fermilab), Brian Kincaid (LBNL), Sam Krinsky (NSLS/BNL), John Noonan (APS/ANL), and Ron Yourd (LBNL). DOE observers included Robert Marianelli and Paul Smith from the DOE/ER as well as Stanford DOE staff members John Muhlstein, Bill Franzwa, and Hanley Lee. The SPEAR3 design team’s success was best indicated by Lehman’s final “DOE Action Item” transparency, which was blank.

The SPEAR3 Project calls for reducing the beam emittance by an order of magnitude and increasing the operating beam current by at least a factor of two while preserving long beam lifetimes. This will be done by replacing the existing racetrack FODO magnet lattice and vacuum chamber with a gradient Double Bend Achromat (DBA) lattice (Figure 1) and reduced aperture vacuum chamber while preserving synchrotron radiation beamline locations. Transverse beam size will be reduced by factors of two to five, depending on beamline source point (Table 1), while the subsequent synchrotron radiation focused flux density and beam brightness for wiggler and undulator beamlines will increase by an order of magnitude. This increase, shown in Figure 2, is further enhanced for photon energies above 10 keV from dipole sources due to the higher critical energy from the shorter SPEAR3 bending magnets. As concluded in the report of the SPEAR3 Scientific Workshop (“SPEAR3 Workshop: Making the Scientific Case”, May 29–30, 1997, SLAC Pub SLAC-R-513), these performance improvements will enable new opportunities in Science and Technology Research and will provide unparalleled capabilities in the 1–4 keV spectral region using undulators (Figure 3). Other SPEAR3 Project goals include raising the injection energy...
from 2.3 GeV to the 3 GeV ring operating energy, providing high beam stability and operational reliability, permitting future accelerator and beamline upgrades, and raising the operating current towards 500 mA. To minimize the impact on the synchrotron radiation users, the SPEAR3 hardware conversion is being planned for a 6-month shutdown period, preceded by earlier 2 to 3-month shutdowns for site preparation and preliminary component installation. Design and implementation details can be found in the “SPEAR3 Conceptual Design Report”, planned for final publication in the fall of 1998.

The SPEAR3 Review agenda for the first day and morning of the second day is shown below. The afternoon of the second day was devoted to several break-out meetings between reviewers and the SPEAR3 design team to discuss the system cost estimates and implementation schedules in more detail. The morning of the third day was reserved for reviewers to write their closeout reports and to prepare summary presentations for the afternoon closeout meeting.

The overwhelming conclusion of the Review Committee was that the SPEAR3 accelerator physics analyses, system designs, cost estimates and project plans are in excellent shape and that the DOE should have little concern in proceeding full force with the upgrade project. The most significant technical recommendation was that component installation and magnet stabilizing measures might be simplified if magnet and vacuum chamber sections were assembled and aligned on new support stands before installation instead of mounting these components on the existing girders in the tunnel as planned. Reviewers also recommended that the development of components on the critical path or having significant technical challenges should proceed as quickly as possible. These include the deep-drawn formed stainless steel vacuum chambers, the high speed digital control links for fast orbit feedback magnet power supplies, the IGBT kicker pulsers (in collaboration with NLC developers), and the highly stable main dipole power supply.

Most other Review recommendations concerned the need for careful and detailed planning and orchestration of procurements and installation scenarios for the fast-paced project, emphasizing the short implementation timelines and the formidable challenge of replacing a storage ring in six months. The Committee lauded the plan to use the powerful Project Management

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Computing System (PMCS), developed for the PEP-II Project, to carry out SPEAR3 project planning and reporting. Regarding the 6-month installation, the Committee reiterated the clear need for maximizing the amount work done in prior short shutdowns. In addition, they recommended that the future SPEAR3 user community, which might be interested in extending the shutdown period to maximize accelerator system quality, be represented on SPEAR3 advisory committees as well as the present user community, which in general is interested in minimizing the interruption of research at SSRL. Above all, the Reviewers urged the DOE to proceed immediately to define and actualize a real SPEAR3 funding scenario as soon as possible so that vital design development can proceed, and critical new staff members, many presumably coming from other SLAC divisions, can be secured in a timely manner.

The SPEAR3 design team members, which include many other contributors besides those identified above, are to be commended for their technical excellence and heroic efforts in producing a Conceptual Design Report and preparing for the Lehman Review over the last year. Their work has gone a long way towards shedding new light and ensuring a bright future.

The LCLS

—Roger Carr

The major events of the past year for the Linear Coherent Light Source (LCLS) were the Technical Review on November 10–12, the publication of the Design Study Report in April, and the preparation of the Visible-Infrared SASE Amplifier (VISA) free electron laser experiment to be performed at Brookhaven. The LCLS is a proposed free electron laser that uses the last kilometer of the SLAC linac and a 112 meter long undulator to create coherent x-rays of wavelength between 15 and 1.5 Å. These x-rays would come in pulses only 233 fsec long, and with peak brightness about 10 orders of magnitude greater than present third generation storage ring sources. The extremely short pulse length, diffraction-limited coherence, and extreme brightness offer entirely new regimes of capability for new experiments, or new approaches to contemporary experiments.

A BESAC panel on synchrotron user facilities, chaired by Robert Birgeneau and Z.-X. Shen last year included in its highest priority, recommended funding for research and development of fourth generation light sources. The DOE is soon to form another panel, chaired by Professor S. Leone of the University of Colorado, to make recommendations for fourth generation light source development.

The LCLS Design Study Report presents a candidate design for the entire LCLS, including the RF photocathode electron gun, modifications to the linac to compress the resulting electron bunches, the design of the undulator and proposals for x-ray optics downstream from the source. Extensive modeling of the x-ray FEL generated a set of electron beam parameters required from the photocathode gun and the linac, and a set of tolerances that the undulator has to meet for efficient FEL gain. Certain challenges arose, such as the requirement for extremely small emittance from the gun, the problem of coherent synchrotron radiation effects in the bunch compressor, the alignment of the undulator, and beampipe roughness in the undulator, that will require further study. The self-amplified spontaneous emission process (SASE) also needs to be more thoroughly investigated. However, none of these problems is thought to be unsolvable, and strategies to deal with each of them were developed.

The Technical Review was a three-day presentation of the contents of the Design Study Report to a national committee of experts in all the subjects relevant to the LCLS. Their report, written by chairman Joe Bisognano of the Jefferson Labora-

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tory, gave its overall approval to the design, said that there were now show-stoppers to the LCLS, and said that the R&D goals were reasonable.

The major activity of the LCLS group this year has been the VISA R&D study of the SASE process. A UCLA/LANL/SSRL/Kurchatov collaboration performed last year an experiment at Los Alamos that showed record SASE gain of $10^3$ at a 12 micron wavelength. This year, a UCLA/BNL/LANL/SSRL-SLAC collaboration is building the 4 m, permanent magnet VISA undulator to be installed on the ATF linac at Brookhaven. VISA is expected to show SASE gain to saturation for the first time, and will emit in the visible wavelength range where silicon detectors can be used to characterize the output radiation. The success of this experiment will provide additional verification of SASE-FEL physics, which is essential for operation at x-ray wavelengths. Data taking on VISA is scheduled for January–February, 1999.

SASE FEL’s operating at shorter wavelengths are being built at APS and DESY and are also expected to begin operation in 1999.

The Gun Test Facility

~John Schmerge

The Gun Test Facility (GTF) at SSRL was started in 1996, with collaborators from across the country including the University of Rochester and Argonne National Laboratory, to develop an appropriate injector for the proposed LCLS. The GTF is located in the SSRL injector vault. The LCLS requires a very bright electron beam to generate coherent x-rays at 1.5 Å. In order to keep the x-rays interacting with the electron beam through the length of the LCLS wiggler, the electron beam must have a very small spot size and divergence angle. The product of the spot size, divergence angle and Lorentz factor $\theta$ (normalized beam energy) is the normalized transverse emittance which is conserved through the length of the linear accelerator (assuming no spoiling effects due to interaction with wake fields, synchrotron radiation in a pulse compressor or other effects). Thus in order to deliver a beam with the appropriate emittance to the wiggler, the injector must be capable of producing a beam with the desired emittance. To date, the lowest measured emittance with a 1 nC electron beam is approximately 2 mm-mrad which would require a significantly longer LCLS wiggler than the proposed 100 m. Therefore the GTF was constructed, including photocathode drive laser, RF power stations, SLAC linac section, and electron beam diagnostics, during the previous two years to characterize electron guns in order to produce the necessary electron beam to drive the LCLS. The required LCLS beam parameters are $= 1$ nC of charge, a normalized transverse emittance of $= 1$ mm-mrad and approximately 10 ps bunch length. The best candidate to delivery the necessary electron beam is the emittance-compensated photocathode RF gun developed at Los Alamos National Laboratory.

Construction of the GTF was completed in fiscal 1998 with the installation of an emittance-compensating solenoid. Previously, the photocathode RF gun, cathode drive laser, klystrons, 3 m SLAC linac section and electron beam diagnostics had been installed. The first gun being characterized at the GTF is the result of a SSRL, SLAC, Brookhaven National Laboratory (BNL) and UCLA collaboration. The first copy of this gun underwent initial testing by Dennis Palmer of SLAC and X.-J. Wang at BNL in FY’97. The major advantage of the GTF RF gun over other laboratories with photocathode RF guns is the ability to perform temporal pulse shaping on the laser and thus produce temporally shaped electron beams. According to simulations, altering the temporal laser profile from a Gaussian pulse shape to a flat top pulse shape will reduce the emittance from the

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Aforementioned state-of-the-art (2 mm-mrad) to the level required for the LCLS.

After installation of the solenoid, commissioning and debugging of the GTF was started. One of the major hurdles to overcome was the challenge of timing the laser pulses to arrive at the correct phase of the RF field in the electron gun. The laser must be timed to the RF field to within 1 ps timing error. This was eventually accomplished at the GTF without the need for a feedback system controlling the exit time of laser pulses by using the laser pulses themselves as the master clock instead of tying all of the equipment to an external clock. The addition of feedback will now further reduce the timing error.

A streak camera has been employed at the GTF to measure the laser pulse shape and pulse duration. The GTF can produce a Gaussian pulse with a continuously variable pulse length from 4–20 ps FWHM. Temporal pulse shaping has also begun using both a time domain technique of splitting, delaying and summing pulses (pulse stacking) to a frequency domain technique using an amplitude mask in the Fourier plane. The expected optimal pulse shape to produce the lowest possible emittance is an approximately flat-top pulse. Both techniques have the ability to produce the desired pulse.

Commissioning has recently been completed and emittance measurements with 1 nC of charge as a function of laser pulse length were just completed in August. The emittance was measured to be 25% lower using a 9 ps long Gaussian laser pulse instead of a 5 ps long pulse. The results obtained to date are consistent with simulations and additional measurements will be made with flat top laser pulses to determine if an emittance of 1 mm-mrad can be obtained. Additional diagnostics are being installed to improve the accuracy of the emittance measurements and to measure the electron beam pulse length. Emittance measurements as a function of laser pulse shape is expected in 1999.

SSRL Welcomes New Accelerator Physicist

–Max Cornacchia

We are pleased to announce a new member of the Accelerator and FEL Physics Group, James Safranek. James’ main tasks will include monitoring the performance of the SPEAR accelerator complex and conducting studies to understand and improve it. He will propose hardware and instrumentation improvements and will work with the engineers to implement the improvements and coordinate task forces to address broad accelerator problems when needed. He will be working with the Operations Group in optimizing the accelerator operational parameters. James will also participate in the design and eventual construction and commissioning of the SPEAR3 upgrade.

James did his Ph.D. thesis work with Helmut Wiedemann at SSRL working on the design and implementation of low emittance optics. After earning his Ph.D. he moved to the NSLS, where, as “studies manager” his goal was to improve the performance and reliability of the accelerator. He is credited with various improvements to the x-ray ring, including the reduction of horizontal-vertical coupling to the level of 0.1%, with a resulting considerable improvement in brightness. He came back to SLAC to work on the PEP-II project. We are fortunate to have such a talented and experienced physicist working to understand and improve the performance of our light source.
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