Section 1

Critical Skills Development

Supported by the
Department of Energy
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Laboratory Critical Skills: Training the Next Generation

Since its inception in the early 1940s, Los Alamos National Laboratory (the Laboratory) has worked hard to maintain the national security of the United States. As the present generation of scientists, engineers, and technicians nears retirement, the Laboratory stands to lose a great deal of corporate knowledge and expertise that in many cases is unique or at the very least esoteric. Without these critical skills, the Laboratory no longer could successfully carry out its national security mission.

Fortunately, the exuberance and infectious enthusiasm of these personnel make them ideal mentors for the current generation of students. Recognizing this, the National Nuclear Security Administration (NNSA) of the Department of Energy has worked with the Laboratory to establish a "student pipeline" designed to attract and subsequently hire new talent into critical positions at the Laboratory.

The Critical Skills Development Program supports laboratory-initiated projects that address critical skill needs at the Laboratory. Although customized to meet specific needs, these projects have in common a number of characteristics. Each project is

- driven by specific critical skill needs identified by Laboratory line management,
- designed by Laboratory management with well-defined objectives and measurable evaluation criteria,
- funded jointly, and
- structured so that students spend an extended period working at the Laboratory.

In Fiscal Year 2002 (FY02), the project included nine programs. The disciplines covered by the programs included the following:

- Physics
- Modern *f*-Element Chemistry
- Radiochemistry
- Engineering
- Supercomputing
- Robotics
- Mathematics
- Computer System Administrator Development
- Materials Science
- Applied Science

The project met the goal of identifying and recruiting highly qualified students for the Laboratory critical skills pipeline in FY02, while strongly impacting all of the DOE/DP Campaigns.

Applied Science Internship Program

"This summer I was still able to have one of those incredible experiences that makes me so excited about a new field of work that I'm forced to reconsider every decision I thought I had made about the direction my life was headed. I learned more than I ever had in class, and watched my projects get applied to experiments that could one day change the world."

Cameron Bass, engineering major, Massachusetts Institute of Technology

Program Description. The fiscal year 2002 (FY02) Applied Science Internship Program (ASIP) extended and formalized a grassroots undergraduate experimental training program in the Physics Division at Los Alamos National Laboratory (LANL, the Laboratory), specifically, in the Plasma Physics Group (P-24) and the Subatomic Physics Group (P-25). Our best hope for recruitment of future generations of LANL technical staff members is through a student program targeting applied science and engineering skills (physics and engineering of lasers, pulsed power, accelerators, inertial confinement fusion, high-energy density physics, and weapons aspects of dynamic experimentation and diagnostics and underground experimentation). ASIP adds an essential component to our student pipeline by providing two avenues for recruitment to supply the Laboratory's future workforce. First, continued support of students throughout their academic careers increases the likelihood that they will choose a career at the Laboratory. Second, ASIP expands the process by networking with academia. The program focuses on near-term hires and on undergraduate- and graduate-level students.

ASIP is a joint venture between the Physics Division (P Division) and several institutions including the New Mexico Institute of Mining and Technology (NM Tech) in Socorro, the Massachusetts Institute of Technology (MIT), and Northern New Mexico Community College (NNMCC) in Española. The Condensed Matter and Thermal Physics Group (MST-10) at LANL has also become involved and has specific experimental programs already in place that offer exciting student projects in plasma physics, shock physics, pulsed power, hydrodynamics, detector development, diagnostics, ultrafast laser science and technology, inertial confinement fusion, laser target design, data acquisition, and more.

The large, continuing, year-round student population of ASIP has created a culture that is luring more high-quality students to the Laboratory. ASIP is continually bombarded with excellent resumes elicited by word-of-mouth recommendations from our alumni, and we find jobs for many students we cannot hire ourselves because of funding and space limitations. P-24 presently has a 30% return rate for students and hopes to increase this percentage next year. In addition, P Division is committed to hiring new staff members from the program, will commit staff members to develop the curriculum, will provide staff support for development of associate's-degree, bachelor's-degree, master's-degree, and doctoral curricula, will implement distance-education media, and will recruit students to fill the program.

Project Goal, Objectives, and Milestones. The goals of this project are to recruit students to the Laboratory and rapidly train them to be contributors to the Stockpile Stewardship Program, to develop and hire highly qualified students into the Laboratory critical-skills pipeline, and to provide a reliable source of exciting jobs and feedback on curriculum development for local institutions so that they can attract higher quality students (Table 1).

Table 1. FY02 Milestones. (All milestones were met.)

Date	Activity
December 2001	Establish a technical steering committee
February 2002	Define the scope of research programs and curriculum in committee
	Advertise student positions for 2002, 2003
March 2002	Hold LANL competition for research project proposals
May 2002	Match students with projects
June 2002	Bring first students to the Laboratory

Partners and Increased Leveraging of Resources. LANL line-organization contributions increased in FY02 to more than a 50% match for overall costs, which are leveraged because the existing programs are already in place. Students this year worked on significant and unique experimental infrastructures such as the TRIDENT laser facility, the Magnetized Target Fusion project, the RSX Magnetic Reconnection experiment, and ultrafast pulse laser experiments. See Figures 1 through 3 for examples of how students have contributed to some of these projects.

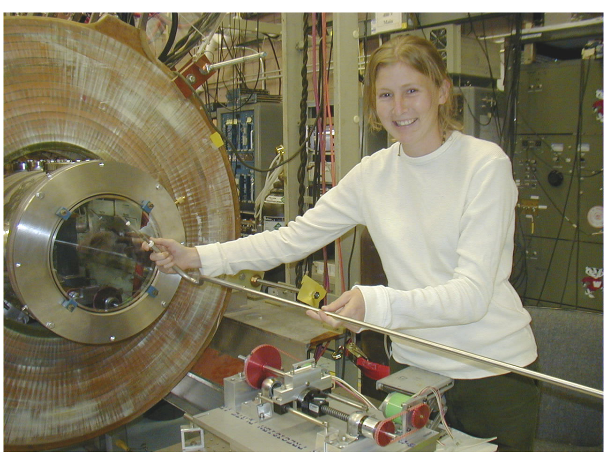


Figure 1. Student Emma Torbert (Princeton) shows off a 3D probe drive she helped conceive, design, and build for RSX.

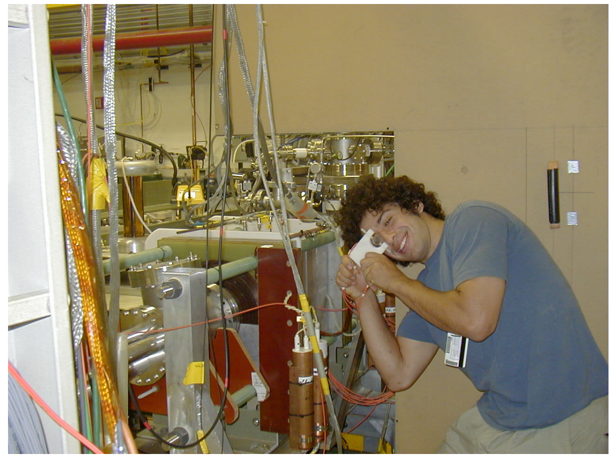


Figure 2. Cameron Bass (MIT) shows pieces of his optical fiber-optic detector array for FRX-L.

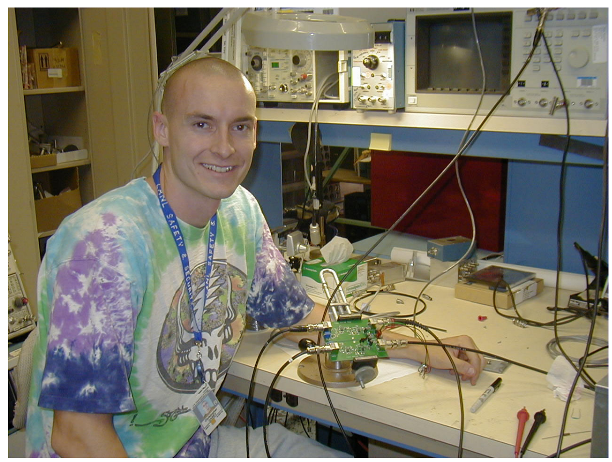


Figure 3. Student Christopher Carey at RSX shows off the preamplifier he developed with high-gain (500), high-input impedance (5 kΩ), high bandwidth (GBW = 2 GHz) for his photomultiplier tube detector array.

Our larger facilities are beyond the capabilities of the universities, and our smaller projects are unique and at the forefront of experimental science. The P-24 summer school attracts audiences two to three times larger than our current 16 students (see Figure 4). P Division is committed to hiring new staff members from the program and will commit its present staff to developing the curriculum and recruiting students to fill the program.

Recruitment Strategies Are Beginning to Succeed. We encourage a steadily increasing

Figure 4. More than 40 students came to this well-attended P-24 summer school session.

fraction of work-study semesters at LANL. What this means is that more and more students spend more than just a summer at the Laboratory. This development benefits students because they get a continuous research experience with concrete and publishable results that appear in peer-reviewed journals. This approach also allows the long learning and training curve (two months or more) necessary for sophisticated work in a national-laboratory environment. We also send students to conferences and symposiums where they not only present their work, but also network with their peers and attract more students to LANL. We encourage return internships for multiple years, and an increasing number of students are taking advantage of this possibility.

Implementation, Evaluation, and What We Learned. We established a small ASIP technical steering committee to define the relevant research programs at LANL and recruit students. In FY02 we made progress in defining and building the educational program, but we have not yet needed to implement distance-education media. Funding to implement the program and to enable the recruitment of students, mentors, and instructors is being pursued during the development stage for FY03.

We have done an informal survey of the students and mentors to evaluate the pilot program. Mentors feel that the student population is a net win in productivity—that the time spent mentoring gets a better-than-even return on useful hardware and research results. The students enthusiastically endorse their LANL experiences. Figure 5 shows the students having fun while learning.

We are tracking what fraction of students return to LANL for study or jobs (approximately 30%), and author or coauthor articles in peer-reviewed literature (also about 30%). We have experience with a student population that has increased every year for the last three years.

Finally, we have reached and exceeded the critical mass required to create a vibrant student culture that allows newcomers to walk in the door at any given time (they arrive sporadically) and integrate easily with the existing milieu. It turns out that the minimum number of students necessary to produce such good results is in the range of 10 to 12 for a local set of Laboratory experiments where the students see each other at least several times per week. This environment is good for the students but places a lot of work on the shoulders of the mentors. We need to spread the students among more mentors next year.

The P-24 summer school was a success, primarily as a “gee whiz” introduction to a diverse array of projects and disciplines that exist at LANL, but we need more formalized, in-depth, and academic course structure, beyond the once-per-week frequency we have tried thus far. Student programs that allow for multiyear commitments, possible graduate theses, and longer-term relationships with LANL are encouraged. We are trying to persuade MIT to reinstate these precepts in relevant programs.

Figure 5. This device is a student-built trebuchet siege engine for launching watermelons across a parking lot in White Rock. Shown left to right at back are students E. Torbert, R. Aragonez, C. Carey, M. Kozar, J. Liang, C. Bass, B. Fienuup, K. Campbell, and M. Cash. Those shown left to right in front are student S. DeVries and mentor I. Furno.

Student housing is still a critical bottleneck for summer students, and by late February all the LANL-sponsored housing apartments downtown are booked up. We would like to find more housing possibilities for students. We have relied on networking with our own students and staff members, but in the longer term, we still don't have a good solution. One possibility would be to lease apartments with the understanding that visiting scientists, scholars, and students would fill them all year. LANL, however, evidently has a minimum-average-occupancy regulation that makes it impossible to guarantee occupancy ahead of time.

Highlights of This Year's Accomplishments. In FY02, the ASIP program recruited a record number of students (12 for P-24 alone). Schools represented included MIT, NM Tech, Stanford University, Princeton University, NNMCC, the University of California at San Diego, the University of Oxford, Purdue University, and the University of Michigan.

Three students are interested in doing a graduate thesis at the Laboratory, and one is being groomed to become a technician next year.

Three students are staying at the Laboratory beyond the summer, and four will be returning in FY03, helping us toward our ultimate goal of longer-term student productivity from a significant year-round student population.

Several student-written publications are in various stages of the peer-review process.

A summer school seminar series that typically attracts more than 30 students was coordinated with two other student programs—Summer School in the Physical Sciences for Undergraduates and the Los Alamos Dynamics Summer School.

Tom Intrator received a P-Division student-mentor award and an MIT School of Engineering Undergraduate Practice Opportunities Program (UPOP) Internship Excellence Award that carried with it a $2,000 stipend for each MIT UPOP student who interned at P-24. The stipend is a significant inducement to top candidates, who have many other choices and are faced with a limited pay scale at the Laboratory.

For an exciting adventure while networking in the scientific community, we are sending four students to the next annual American Physical Society

Plasma Physics Meeting in November 2002. As word of this plan spreads, we are attracting increasing local interest. It appears that our large, continuing year-round student population creates a culture that lures even more students here. We also are getting bombarded with excellent resumes elicited by word-of-mouth recommendations from our alumni, and we are obliged to find LANL jobs for many students we cannot hire ourselves. P-24 presently has a 30% return rate for students, and we predict a 50% return rate for a larger pool next year.

Appendix A. List of Students in 2002

A large list of excellent students was recruited for this year (see Table 2). Some students with full and partial fellowships (MIT UPOP, University of Michigan Department of Energy [DOE] Fellows, Summer School in the Physical Sciences [SSPS]) have chosen to profit from our local Laboratory environment. This situation expands our community at zero or reduced monetary cost to us. National Undergraduate Fellowship (NUF) fellows and MIT students in the Engineering Internship

Table 2. List of Students in 2002

Last Name	First Name	Institution	Status	Honors	Returning Student	Group
Aragonez	Richard	NNMCC	UGS (undergraduate student)			P-24
Bass	Cameron	MIT	UGS	UPOP stipend		P-24
Campbell	Kyle	NM Tech	GS (graduate student)			P-24
Carey	Christopher	Ohio State	UGS	NUF Fellow		P-24
Cash	Michelle	Stanford	UGS	NASA Fellow		P-24
DeVries	Sean	University of New Mexico-Los Alamos	UGS		X	P-24
Fienup	Bill	MIT	UGS	EIP, LANL UGS prize	X	P-24
Harris	Margaret	Luther College	UGS	LANL SSPS Fellow		P-24
Kozar	Michael	Princeton	UGS	NUF Fellow		P-24
Liang	Joanna	MIT	UGS	UPOP stipend		P-24
Martinez	Rafael	University of Michigan	UGS			P-24
Niemczura	Jonathan	MIT	UGS	EIP	X	P-24
Pangilinan	Monica	Cornell				MST-10
Renneke	Richard	Purdue	GS	Purdue Fellowship		P-24
Teslow	Hilary	University of Michigan	GS	DOE Fellowship		P-24
Torbert	Emma	Princeton	UGS	LANL UGS prize		P-24
Vermare	Laure	University of Bordeaux	GS		X	P-24
Werley	Kit	Stanford	UGS	LANL UGS prize	X	P-24
Woode	Ebenezer	MIT	UGS	UPOP stipend		MST-10

Program (EIP) are likely to do graduate work and write theses at LANL.

Appendix B. List of FY02 Mentors (Table 3)

Table 3. List of FY02 Mentors

Mentor's Last Name	Initial	Group
Averitt	R.	MST-10
Cobble	J.	P-24
Furno	I.	P-24
Intrator	T.	P-24
Paisley	D.	P-24
Sanchez	P.	P-24
Taccetti	M.	P-24
Wurden	G.	P-24

Appendix C. List of Publications Involving Students in 2002

(Students' names are shown in bold-face type.)

1. *Overview of High-Density FRC Research on FRX-L at Los Alamos National Laboratory*, J. M. Taccetti, T. P. Intrator, S. Y. Zhang, G.A. Wurden, R. J. Maqueda, M. Tuszewski, R. Siemon, D. Begay, E. Mignardot, P. Sanchez, B. Waganaar, **R. Aragonez, C. Bass, J. Liang, R. Renneke, M. Kozar**, C. Grabowski, E. Ruden, J. H. Degnan, and W. Sommars, *Proceedings of U.S.-Japan Workshop for High Beta Plasmas*, September 2002, Osaka, Japan.
2. *Reconnection Scaling Experiment: A New Device for Three-Dimensional Magnetic Reconnection Studies,* I. Furno, T. Intrator**, E. Torbert, C. Carey, M. D. Cash, J. K. Campbell, W. J. Fienup, C. A. Werley**, G. A. Wurden, and G. Fiksel, submitted to *Rev. Sci. Instrum*. (2002).
3. *Novel Rogowski Probe for Use in Plasma Environment*, E. Torbert, T. Intrator, I. Furno, **M. D. Cash**, submitted to *Rev. Sci. Instrum*. (2002).
4. *Magnetic and Visible Emission Data Showing Magnetic Reconnection in the Reconnection Scaling Experiment,* T. Intrator, I. Furno**, E. Torbert, C. Carey, M. D. Cash, J. K. Campbell, W. J. Fienup**, R. Maqueda, **C. A. Werley**, G. Wurden, and G. Fiksel, in preparation for *Physics of Plasmas* (2002)
5. *Characterizing a High-Density Field-Reversed Configuration Device for Magnetized Target Fusion*, **T. Renneke**, T. Intrator, J. M. Taccetti, G. Wurden, W. Waganaar, and R. Siemon, *Bull. Am. Phys. Soc*., November 2002.
6. *Constructing a Bolometer Array Diagnostic for the FRX-L Plasma***, M. Kozar**, G. Wurden, T. Intrator, and J. M. Taccetti, *Bull. Am. Phys. Soc*., November 2002.
7. *Vacuum Control System for Operating the Field Reversed Configuration Experiment (FRX-L) for Magnetized Target Fusion*, P. Sanchez, T. Intrator, J. M. Taccetti, and **R. Aragonez**, *Bull. Am. Phys. Soc*., November 2002.
8. *Photomultiplier Array Detector for Visible Light Emission on the FRX-L Experiment***, C. Carey**, G. Wurden, T. Intrator, and J. M. Taccetti, *Bull. Am. Phys. Soc*., November 2002.

Computer System Administrator Development Initiative

Program Description. Computing is a critical resource at Los Alamos National Laboratory (the Laboratory). The Laboratory has more than 21,000 desktop workstations and servers that provide electronic workplace services to every member of the Laboratory workforce. About 70% of the workstations are used in the weapons program. Drivers such as operating system complexity, the convergence of more technology onto the desktop computer, and the ever-increasing computer security demands require that the Laboratory have a ready supply of very competent and capable computer system administrators.

The Computer System Administrator Development Initiative (CSADI) was designed to recruit students who are enrolled in local colleges and universities and want to develop their skills as computer system administrators in UNIX, NT, and network administration. The project specifically addresses the needs in all Department of Energy/ Defense Programs campaigns at the Laboratory by providing a workforce to maintain stable, secure computing for the programs.

Students are eligible for the internship after they complete the first year of a college degree program in computer science or computer/network administration.

The recruiting strategy has been to develop partnerships with the chairmen of departments at participating institutions, work with them to advertise the internship opportunity during the spring semester, and then include them in the interview-and-selection process. Students working in CCN-2 are shown in Figures 6 through 9.

Performance Goal, Objectives, and Milestones. The goal of this project is to develop and hire highly qualified computer system administrators to support Laboratory computing and the Laboratory mission of Nuclear Stockpile Stewardship.

This first year of the program (FY2002) produced the following milestones:

- The program built partnerships and recruited at three local colleges.
- The program brought in two students from each school under the internship program.

Figure 6. Tay Naish is a CSADI student in CCN-2 learning the "ins and outs" of computing, helping us with the Applied Physics Organization at Los Alamos.

Figure 7. Sal Sena is a CSADI student in CCN-2 working also in the Applied Physics Organization at Los Alamos. Sal specializes in diskless UNIX computing.

- The program developed a mentor network within the Desktop Computing Group at the Laboratory to provide a training and development environment for these interns.

Highlights of This Year's Accomplishments. To date, we have met with three colleges—Northern New Mexico Community College (NNMCC), Santa Fe Community College (SFCC), and the University of New Mexico at Los Alamos (UNM-LA). We began working with the head of the computing department at each school in January to review CSADI and its requirements and to solicit help in advertising the program and identifying the best potential student participants.

In April we began reviewing applications and scheduling interviews. Department chairmen and faculty members from each of the three schools were active participants in the process. We selected six students to participate in the program this year—one from NNMCC, two from SFCC, and three from UNM-LA. Mentors were identified for each of these students. The mentors will guide their development and contributions during their time at the Laboratory. The students have completed their first five-month rotation in the group. Job assignments are rotated in October to give students a broad view of the organization and an opportunity to work with different Laboratory customers and computer environments.

We continue to be delighted with the quality of the students we are seeing in this program. These people are very eager to learn and to work with the Laboratory. They also bring some exciting and fresh new ideas about computing to the Laboratory. The feedback

Figure 8. Nick Miller is a CSADI student in CCN-2 working on our Enterprise Software Management team helping us design and test hardware and software configuration standards for the Laboratory.

we receive from the students is that they really appreciate the opportunity to experiment and to apply their academic knowledge in real computing environments. They also view the Laboratory as a very positive work and learning establishment.

We had six students with us from previous years, and we converted two of them into full-time, permanent technicians as they successfully completed their degrees and their internships. One student was offered a Laboratory contractor position. Two students are still working on their degrees, and one student left the internship.

Figure 9. Crystal Salazar is a CSADI student in CCN-2 working on helping administer PC, Mac, and UNIX systems for the Computing, Communications, and Networking (CCN) Division.

Go Figure!

A Celebration of Math

"As scientists, we must educate and train our replacements early. We must mentor them, nurture them, so that one day they can excel and contribute to the advancement of science. In my career at the Laboratory, I have mentored about 25 students. I enjoy working with them. They bring a lot of energy and a new way of thinking to the projects."

Madhav Marathe, Los Alamos National Laboratory *Go Figure!* mentor

Program Description. The *Go Figure!* Mathematical Challenge (*Go Figure!*, the Challenge) is jointly coordinated by Los Alamos National Laboratory (LANL, the Laboratory) and Sandia National Laboratories (SNL) and funded by the U.S. Department of Energy (DOE)/Defense Programs (DP). The Challenge is dedicated to strengthening the mathematical capabilities of our nation's young people by identifying, recognizing, and rewarding those students talented in mathematical thinking. Other goals include: engaging talented students and involving them with the laboratories in summer internships to increase the likelihood of recruiting them as permanent employees; understanding and mastering the development of *Go Figure!* problems and solutions to ensure continuance of the program as an alternative method for identifying talent; and increasing interest in mathematics and developing problem-solving abilities through friendly yet challenging mathematics contests. Students participating in the program are reminded that mathematics and algebra are the building blocks for all of the scientific disciplines and that without these foundations their career opportunities will be severely limited.

Go Figure! targets students from grades 7 through 12 in northern New Mexico and provides them with an opportunity to participate in problem solving and enriching mathematical experiences. The program is intended for everyone from the average student who enjoys mathematics to the very best student who excels in mathematics.

Participants are offered 13 problems and given two and a half hours to solve them. Problems selected require a minimal amount of knowledge and a great deal of creativity, originality, and analytical thinking. When the contest is graded, credit is given for supporting work so that originality and creativity are rewarded.

Preregistration is not offered, and there is no restriction placed on the number of participants. The program avoids putting schools in the position of deciding who will represent them because in most cases, they would choose "A" students, a process that would not always identify those with the most mathematical talents and the most creativity—the ones the contest seeks.

Go Figure! recruitment strategies included site visits to schools by the Laboratory program coordinator and Laboratory technical staff members, local radio and TV public service announcements, news releases run in local newspapers and the Laboratory Newsbulletin, and information provided on the *Go Figure!* website. This fall, the San Juan College radio station, KSJE 90.9 FM, (Ray Francis, director), ran a series of *Go Figure!* announcement spots and conducted interviews with past *Go Figure!* participants and coordinators in an effort to increase awareness of the fall contest. Home-schooled students were encouraged to participate in *Go Figure!* in the fiscal year 2003 (FY03).

Implementation of new programmatic components in fiscal year 2002 (FY02) boosted *Go Figure!* to a higher level of success. We developed and implemented a Summer 2002 Institute at the Laboratory and recruited winners to participate in summer internships under the guidance of outstanding mentors. The institute included hands-on, minds-on activities, tours of the Laboratory, and opportunities to meet and work with Laboratory mathematicians, computational scientists, and nuclear engineers.

Improvements in FY02 also included the development of a database to track students during their college years. The goal is to maintain contact and recruit the most promising students for internships and positions in college-level Critical Skills Development Program activities at the Laboratory. During FY03, we plan to improve the *Go Figure!* program by recruiting student participants from three Santa Fe schools—Santa Fe Indian School, Santa Fe High School, and Capital High School. We also plan to involve mathematics teachers more fully, hold the traditional banquet in Farmington and a new banquet in Santa Fe, and improve our recruitment and advertising strategies. Many of these improvements have been initiated or planned as part of the process of jointly developing goals for *Go Figure!*.

(For more about *Go Figure!*, go to http://education.lanl.gov/newEPO/k12/GoFigure/math.htm.)

Performance Goals, Objectives, and Milestones. Overall goals for the *Go Figure!* competition (developed jointly with SNL staff members and the director of the DOE/DP Office of University Partnerships) are as follows:

- identify students talented in mathematical thinking;
- engage parents and the community in recognizing and supporting talented students;
- engage teachers in *Go Figure!* with the intent of stimulating them to be better math teachers;
- engage talented students and involve them with the Laboratory as student employees or in other capacities to aid in their development and make their successful recruitment as professional staff members more likely;
- increase the diversity of the Laboratory pipeline by targeting students from underrepresented populations.

The main performance objective of *Go Figure!* is to enhance the supply of well-qualified mathematicians, especially at the Laboratory, by providing tools and resources to prepare students for induction into the workforce pipeline. The goal is to create a renewed interest in mathematics in northern New Mexico by encouraging student confidence in mathematics and fostering connections between content knowledge of mathematics and its application in the area of national security. Many students first develop an interest in mathematics through problem-solving activities such as *Go Figure!*. Through the development and promotion of such programs, we can promote an improvement in the attitudes of teachers, students, and their parents toward the ability to understand and apply mathematics.

In addition to expanding the program in FY02 to include a broader geographical area, we strengthened its involvement with the Northern New Mexico Council for Excellence in Education's Mathematics and Science Academy (MSA) as a recruitment avenue for promoting the contest. The association with the MSA is, by all accounts, a positive influence on *Go Figure!* recruitment efforts. Both the MSA and *Go Figure!* are viewed as "good neighbor" initiatives on behalf of the Laboratory.

Table 4 lists FY02 milestones. Throughout the *Go Figure!* experience, students and teachers are encouraged to develop a web-based communications network. The intent is to create a strong educational support network among the participants and their surrounding higher learning institutions including the Laboratory and San Juan College. Students also are encouraged to take practice tests and view previous years' exams on the website to prepare better for the contest.

Table 4. FY02 Milestones. (All milestones were met.)

Date	Activity
October 27, 2001	Hold the annual *Go Figure!* Mathematics Competition
November 15, 2001	Hold the *Go Figure!* Banquet in Farmington
January 2002	Contact students and recruit for the 2002 *Go Figure!* Summer Institute and internships
February 2002	Identify mentors/projects for undergraduate internships
April 2002	Complete plans for the Summer Institute; locate housing for students
May 2002	Complete plans for the institute agenda, tours, and activities
June 2002	Conduct Summer Institute 2002
August 2002	Begin the advertising campaign to recruit participants for the competition in October; prepare sites and train moderators for the competition
September 2002	Meet with school principals; begin planning the banquet; prepare the award letter, news releases, and announcements; engage teachers; recruit keynote speakers
October 2002	Complete presentations in mathematics classrooms at each participating school; follow up with students who were involved in summer 2002 activities
October 19, 2002	Hold the annual *Go Figure!* Mathematics Competition; send letters to winners and finalists; complete banquet plans
November 2002	Hold *Go Figure!* Banquets in Farmington and Santa Fe

Highlights of this Year's Accomplishments. The highly successful Four Corners *Go Figure!* Mathematical Challenge was held on October 27, 2001. There were 62 student participants from the seventh through the 12th grades. The contest was held at San Juan Community College (in Farmington, New Mexico), and at Los Alamos Middle School, Española Middle School, and Cuba Middle School. The Laboratory sponsored all four contest sites. Contest participants accepted the challenge of a two-and-half-hour test on problems that ranged from easy to very difficult. Most enjoyed the contest and found it mentally stimulating and challenging.

A banquet honoring the winners of the contest was held in Farmington in November 2001. The highlight of the evening was a presentation by Vernon Willie, a professor at San Juan Community College. The banquet was well attended, drawing students, teachers, and parents.

The following books were awarded as prizes. They were given to the winning students from each grade level for their achievement in the 2001 *Go Figure!* Mathematics Challenge:

- "Enjoyment of Mathematics: Selections from Mathematics for the Amateur," by Hans Rademacher and Otto Teoplitz, IBSN 0-691-02351-4.
- "What is Mathematics? An Elementary Approach to Ideas and Methods," 2nd Edition, by Richard Courant et al., ISBN 0-19-510519-2.
- "Mathematical Discovery, Combined Volume," by George Polya, IBSN 0-471-08975-3.
- "How to Solve It," by George Polya, IBSN 0-691-02356-5.
- "Number Theory and Its History," by Oystein Ore, ISBN 0-486-656209-9.
- "The Wohascum Country Problem Book," by George Gilbert et al., ISBN 0-88385-316-7.

As in previous years, Abraham Hillman, a Professor Emeritus (in Mathematics) at the University of New Mexico, was an invaluable contributor to the development, implementation, and success of the 2001 *Go Figure!* Challenge. It will be important to capture the essence of Hillman's pedagogy in planning, grading, and recruiting in order to scale up the implementation of *Go Figure!* as it grows in popularity.

The highlight of this year's program was Summer Institute 2002, held in June. The institute, designed to provide students with an educational experience in working with technical staff members on a mathematical, computer-simulated project, involved seven students, ages 15 to 17. While they were at the Laboratory, the students were under the direction of Madhav Marathe, project director of Basic and Applied Simulation Science (D-2). They also took tours of the Los Alamos Neutron Science Center and the Nicholas C. Metropolis Center for Modeling and Simulation.

The students worked with Marathe on a project called Transportation Analysis SIMulation System (TRANSIMS) that requires computer simulation and mathematics. TRANSIMS (http://www-transims.tsasa.lanl.gov) is a set of transportation and air quality analysis and forecasting procedures. It consists of mutually supporting simulations, models, and databases that employ advanced computational and analytical techniques to create an integrated regional transportation system analysis environment.

Another accomplishment in FY02 was the recruitment and placement of past *Go Figure!* winner Albert Wang into a summer research position. Wang worked at the Laboratory under the mentorship of Joysree Aubrey of the Hydrodynamics and X-Ray Physics Group (P-22). He worked on machine learning and artificial intelligence techniques to process large sets of data. He will continue his internship as a co-op student during his senior year at Los Alamos High School.

Recruitment for *Go Figure!* was enhanced by a video that Willie and students of Navajo Prep (in the Four Corners area) produced in FY02.

In addition, a website was developed during the summer of 2002 by the *Go Figure!* Summer Institute students to communicate their summer experiences. The participating students were contest winners for the year 2001. The website address is as follows: http://education.lanl.gov/newEPO/k12/GoFigure/StudentPg/main.html.

Our track record in running several successful *Go Figure!* contests serves us well. Working with other *Go Figure!* sites allows us to share successes and lessons learned so that we may provide the students with the best possible *Go Figure!* Challenge experience.

Refinements and improvements are planned in FY03. They will be based on lessons learned this summer and on student evaluations. One planned improvement will be to give the Summer Institute 2003 participants a hands-on experience with the new Powerwall Theater to be completed by spring 2003. Another improvement will be to have the students use the facility to do hands-on work and use supercomputers to solve a mathematical/computer-simulated problem.

Following are some representative comments from *Go Figure!* participants:

> *"I never knew learning could pay off so big. I was merely looking forward to working at the labs later on, but now I can't wait to come back."* Sean Peterson, 10th grade.

> *"It doesn't hurt to know a little math. I know this experience will help me in future endeavors."* Anna Miller, 10th grade.

> *"Los Alamos doesn't have much to do when you're not working, but I'm still having fun. Math has never let me down. It's always opening new doors for me, and look, it brought me to Los Alamos. I am really looking forward to working at the labs again."* Chris Brink, 11th grade.

> *"Math is my best friend. It always helps me out when I need it. Go Figure! has helped introduce me to the labs and is a great program."* Shawn Jia, 11th grade.

"Programs like Go Figure! let young men and women make meaningful connections for possible future employment in a field in which they are already becoming experts."
Kyle Yazzie, 11th grade.

"Go Figure! was an incredible experience. It was enlightening to see how mathematics was applied to the projects and experiments here at Los Alamos National Laboratory."
Brianne Douthit, 12th grade.

"It has been a pleasure working with these Go Figure! Summer Institute students. I feel the summer has been both challenging and rewarding for them, and I look forward to their continued participation in Go Figure!."
Joe Vigil, *Go Figure!* program coordinator.

Los Alamos Dynamics Summer School

Program Description. During the last 20 years, there has been a 20% decline in the number of engineering degrees granted—while university degrees in general have increased approximately 20%.[1] Engineering dynamics, which encompasses areas such as flight dynamics, vibration isolation for precision manufacturing, earthquake engineering, blast loading, signal processing, experimental modal analysis, etc., is naturally affected by this decrease in numbers. The competition for talented individuals with the background necessary to replace those leaving the field of engineering dynamics necessitates a proactive approach to identifying, motivating, and educating students who are embarking on a graduate school career. The Los Alamos Dynamics Summer School (LADSS) was designed with this proactive approach in mind. The program is designed not only to benefit the students through their educational experiences, but also to motivate them to attend graduate school and to make them aware of career possibilities at Department of Energy (DOE) laboratories that will be available to them after they complete their graduate studies.

In fiscal year 2002 (FY02), the LADSS had two focus areas. First, the multidisciplinary nature of research in engineering dynamics was emphasized throughout the summer school. To this end, the students were assigned to multidisciplinary teams and assigned a project in which a coupled analytical/experimental approach to dynamics problems was required. Second, the program was designed to develop the students' written and oral communications skills. To develop these skills, the students were required to give numerous informal oral presentations of their work, culminating in a formal presentation and paper for a technical conference.

A new aspect of the LADSS in FY02 was a guest tutorial by a technical editor from Virginia Polytechnic Institute and State University (Virginia Tech). The students were required to submit a sample of their paper and presentation viewgraphs to the technical editor so that he could provide direct feedback to them after his lecture.

Student Body Profile. In FY02, the LADSS had 15 students. One had completed his first year of graduate school; three were starting graduate school in the fall of 2002; and 11 were preparing for their senior years in college. Most of the students were mechanical engineering majors (14), and one had chosen a civil engineering major. The average grade point average (GPA) for the students was 3.75 on a scale of 4.0. Undergraduate universities represented included Rose-Hulman Institute of Technology, Purdue University, Colorado State University, Virginia Tech, Montana State University (Montana State), Michigan Technological University, New Mexico State University (NMSU), Texas Tech, and the University of Texas at El Paso. Graduate schools that students were attending or planned to attend in the fall included NMSU, the University of Notre Dame, Texas A&M University, and Virginia Tech.

The Projects. The centerpiece of the LADSS in FY02 was an eight-week project having both analytical and experimental components.

The experimental component was a critical aspect of the program because practical experimental activities in engineering dynamics are almost nonexistent at the undergraduate level. Students were placed in teams of three people and assigned a project. An attempt was made to make the groups as multidisciplinary and diverse as possible, and students from the same school were not assigned to any team. Each team had a mentor from Los Alamos National Laboratory (LANL, the Laboratory) or from Sandia National Laboratories (SNL). The mentors worked closely with their groups, providing guidance, encouragement, and technical expertise. All of the projects resulted in papers ready to be presented at the 2003 International Modal Analysis Conference (IMAC). The titles of the resulting papers and their abstracts are listed below.

- *Vibration Modeling and Suppression in Tennis Rackets*
  Abstract: The size of the "sweet spot" is one measure of tennis racket performance. In terms of vibration, the sweet spot is determined by the placement of nodal lines across the racket head. The vibrational characteristics of a tennis racket are explored to discover the size of the sweet spot. A numerical model of the racket is developed using finite element analysis, and the model is verified using experimental modal analysis. The effect of string tension on the racket's sweet spot and mode shapes are then calculated. An investigation is also made to determine how add-on vibrational dampers affect the sweet spot. Finally, optimized racket design for a larger sweet spot is presented. A picture of the suspended tennis racket is shown in Figure 10.

Figure 10. Tennis racket testing.

- *Modal Parameters for a Flat Plate Supported on an Oil Film*
  Abstract: This study examines the modal parameters for a flat plate for four cases: plate freely suspended, plate freely suspended while supported by an oil film, plate fixed at several locations, and plate fixed at several locations while supported by an oil film. The investigation is motivated by the need to understand the bending properties of a square plate on a slip table, particularly with consideration of the damping provided by an oil film. A comparison of support and damping characteristics supplied by an oil film with that provided by equally placed linear bearings will be made. Analytical and empirical data are contrasted and discrepancies discussed. A picture of the instrumented structure is shown in Figure 11.

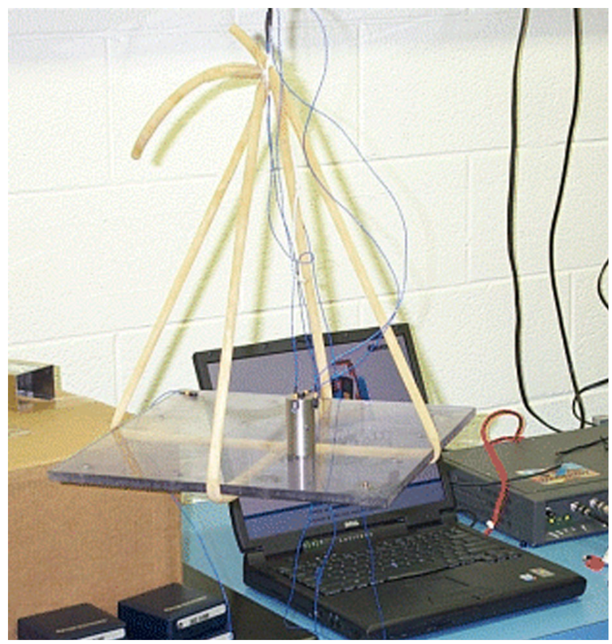


Figure 11. Suspended plate.

- *Active Vibration Damping in the Presence of Uncertainties*
  Abstract: This study addresses the design, implementation, and comparison of active-vibration control strategies for a cantilevered aluminum beam with a

variable mass attached to the free end. Accelerometers will be used as sensors, and a piezoelectric patch will be used as the actuator. The real-time control will be designed using Matlab/Simulink and implemented using a personal computer (PC) running Matlab's xPC Target and equipped with a data acquisition system. This project is motivated by a desire to assess the capabilities of various control design techniques, particularly in the presence of uncertainty and actuator limitations. The performance of the various techniques will also be investigated in the presence of an intentionally introduced nonlinearity. A picture of the beam is shown in Figure 12.

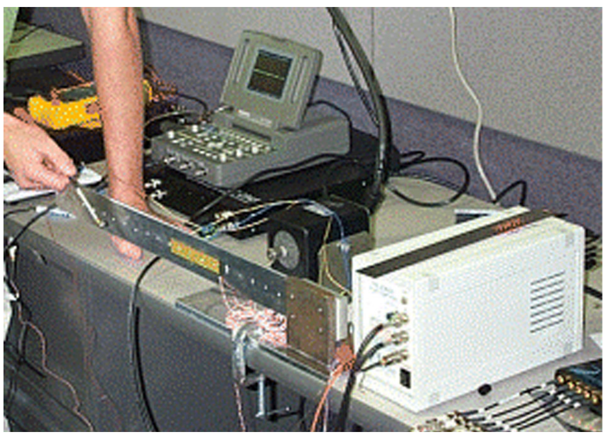


Figure 12. Cantilevered beam.

- *Identification of Random Variation in Structures and Their Parameter Estimates*
  Abstract: Multielement structures that are nominally identical are, in reality, different because of variance between their individual members. Furthermore, there are variations in the system response of an individual structure caused by unmeasured conditions (such as temperature or humidity) that are present during experiments. Finally, noise is present in any measurement of structural excitation or response. For these reasons, error is always associated with the characterizations made about structural dynamic systems, and descriptions of results must be in statistical or probabilistic terms. This study identifies and assesses the sources and the degrees of randomness in the metrics of structural dynamics. A picture of the test structure is shown in Figure 13.

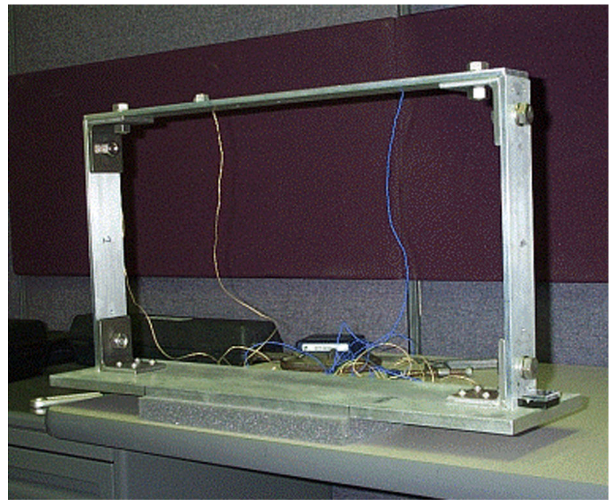


Figure 13. Test structure for random variation study.

- *Identification of Damage Using the Holder Exponent*
  Abstract: A damage-detection strategy that identifies damage-sensitive features associated with nonlinearities is implemented. Some nonlinearities are caused by discontinuities introduced into the data by certain types of damage. These discontinuities may also exist because of noise in the measured dynamic response data or because of random excitation applied to the system. To detect the discontinuities, the Holder Exponent, which is a measure of the degree to which a signal is differentiable, is extracted from the wavelet transform of the acceleration signal. A statistical model was developed—by studying the Holder Exponent as a function of time—that classifies changes in the Holder Exponent that are associated with damage-induced discontinuities. The Holder Exponent was used to detect impacts between elements in the spring-mass system shown in Figure 14.

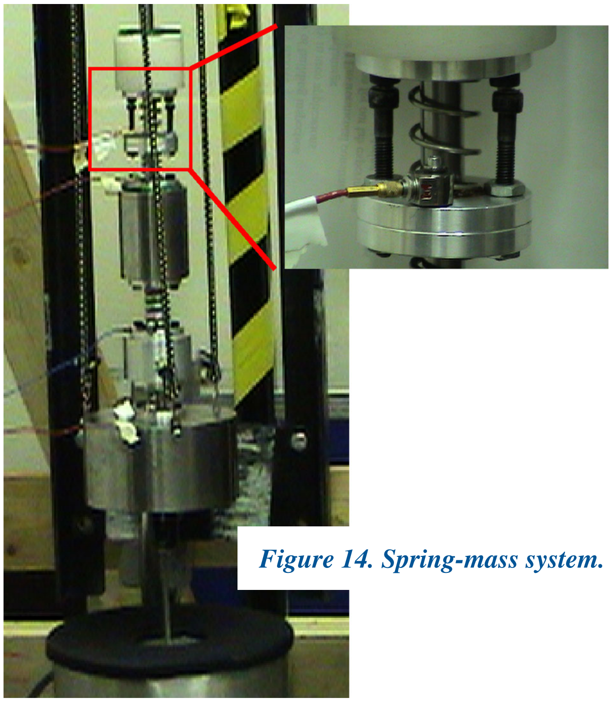


Figure 14. Spring-mass system.

Experimental Equipment. Each student had a high-end PC with numerical analysis and signal processing software. The companies donating software are shown in Table 5.

Each research group had access to a multichannel data acquisition system. Figure 15 shows a student using one of these data acquisition systems. Finite element analysis software was made available to each research group as necessary. Equipment available at the start of the summer included the following:

- 15 PCs with Microsoft Office and numerical analysis and signal processing software;
- a 40-channel Hewlett-Packard Company data acquisition system, three four-channel Dactron Photon dynamic signal analyzers, and two eight-channel Dactron SpectraBook data acquisition systems;
- data acquisition/signal processing software;
- experimental modal software packages (ME'scopeVES);
- various sensors, impact hammers, and small shakers (appropriate to the identified projects); and
- finite element software (ABAQUS).

Field Trips. Several field trips were taken throughout the summer. These trips included tours of the Aging Aircraft Facility, Robotics Facility, and the Microelectronic Facilities at SNL.

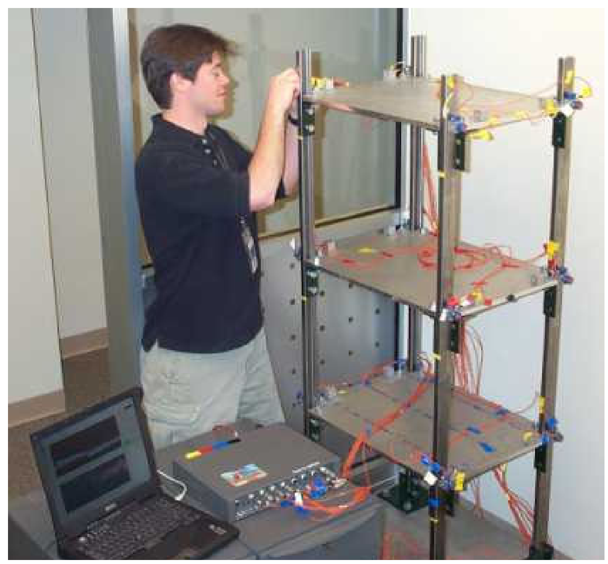


Figure 15. A student using a multichannel data acquisition system.

Table 5. Companies Donating Software for the Duration of the LADSS

Company	Software	Purpose
Mathworks	Matlab (plus all toolboxes and Simulink)	Numerical analysis and signal processing
Hibbitt, Karlsson & Sorensen, Inc.	ABAQUS	Finite element analysis
Vibrant Technology, Inc.	ME'scopeVES	Vibration data analysis

Visiting Distinguished Lecturers. Each week a prominent guest lecturer in the field of engineering dynamics gave a talk to the students about cutting-edge research in structural dynamics. These lecturers and the titles of their talks are listed in Table 6. Most of the lecturers spent two to three days in Los Alamos. In addition to giving one formal presentation, visiting lecturers spent time with the students, discussing their projects and providing suggestions and additional motivation.

Additional Lectures. In addition to the project and the lectures by and interaction with the visiting distinguished scholars, the students received instruction on a variety of topics in engineering dynamics. This instruction took the form of multilecture tutorials on fairly general topics such as random vibrations or computational structural dynamics, and demonstration/application lectures on more specific topics. The titles of the multilecture tutorials are listed in Table 7, and the single-lecture or demonstration/application lectures are listed in Table 8.

A new aspect of the curriculum this year was that all the student groups were required to perform an analytical and experimental modal analysis of a structure. This assignment ensured that each student had a chance to apply the material that was presented in tutorials to actual hardware systems.

Assessment. Students were required to provide written feedback regarding their experiences in the program. This written feedback included evaluations of each speaker, field trips, and the guest lecturers, in addition to a final, overall evaluation of the summer school. The assessment of each speaker and guest lecturer will be used to decide

Table 6. Distinguished Lecturers

Name	Title, Organization	Title of Talk
Michael Alley	Instructor, Department of Mechanical Engineering, Virginia Tech	"Technical Writing Workshop and Presentation Preview"
Dave Brown	Professor of mechanical engineering; director of the Structural Dynamics Research Laboratory, University of Cincinnati	"Modal Analysis Case Histories"
Fred Costanza	Naval Surface Weapons Laboratory, Carderock, Maryland	"Underwater Shock Testing and Analysis"
Frieder Seible	Acting Dean of Engineering, University of California, San Diego	"Seismic Response, Retrofit, and Monitoring of Bridges and Other Critical Structures"
Dan Inman	Director of the Center for Intelligent Material Systems and Structures; George R. Goodson, Professor of Mechanical Engineering, Virginia Tech	"Smart Structures, Structural Health Monitoring, and Control"
Tom Kenny	Associate professor of mechanical engineering; Head of the Micro Structures and Sensors Laboratory, Stanford University	"Micromechanical Devices for Biological Force Measurements"
Charlie Pickrel	Boeing Technical Fellow, the Boeing Company	"Testing and Modeling—Solving Structural Dynamics Problems"
Mike Todd	Head of the Naval Research Laboratory Fiber-Optic Smart Structures Group	"High-Performance Fiber-Optic Sensing"
Dave Zimmerman	Professor and Associate Chairman in Mechanical Engineering; Director of the Dynamic Systems and Controls Laboratory, University of Houston	"Health Monitoring of Structures and Machinery in Zero Gravity"

Table 7. Titles and Presenters of Multilecture Tutorials

Title	Presenter	Title, Organization	Number of Lectures
Rigid-Body Dynamics	Phillip Cornwell	Professor of mechanical engineering, Rose-Hulman Institute of Technology	4
Sensors and Data Acquisition	Chuck Farrar	Staff member, Los Alamos National Laboratory	2
Structural Dynamics	Pete Avitabile	Assistant professor of mechanical engineering; founder and president of Dynamic Decision, University of Massachusetts, Lowell, Massachusetts	3
Experimental Modal Analysis	Pete Avitabile	Assistant professor of mechanical engineering; founder and president of Dynamic Decision, University of Massachusetts, Lowell, Massachusetts	6
Signal Processing	Amy Robertson	Hytech, Inc.	3
Wavelets	Amy Robertson	Hytech, Inc.	2
Controls	Matt Bement	Staff member, Los Alamos National Laboratory	2
Random Vibrations	Tom Paez	Staff member, Sandia National Laboratories	5
Nonlinear Vibrations	Doug Adams	Assistant professor, Purdue University	5
Computational Structural Dynamics	Jobie Gerkin	Staff member, Los Alamos National Laboratory	4
Environmental Testing	Norm Hunter	Staff member, Los Alamos National Laboratory	2

Table 8. Additional Instruction Received by the Students

Title	Presenter	Title, Organization	Number of Lectures
Confinement Vessel Blast Analysis	Bob Stephens	Staff member, Los Alamos National Laboratory	1
Satellite Testing and Analysis	Tom Butler	Staff member, Los Alamos National Laboratory	2
A Rigid-Body Dynamics Code—ADAMS	Ryan Maupin	Staff member, Los Alamos National Laboratory	1
Materials Modeling: A Multiscale Effort	Frank Addessio	Staff member, Los Alamos National Laboratory	1
Model Validation	Francois Hemez	Staff member, Los Alamos National Laboratory	1

which speakers to invite back next year. Overall, the distinguished lecturers were rated highly. The average score was 4.47 on a scale from one to five where a one is "poor" and a five is "excellent." The average rating of the speakers giving the weeklong lecture series was 4.56, and the average rating for the speakers who gave just one or two lectures was 4.42. Note that the ratings are very consistent across the different categories of speakers.

The field trips to the Aging Aircraft Facility, the Microelectronics Facility, and the Robotics Facility at SNL received ratings of 4.23, 4.67, and 4.58, respectively, using the same scale discussed earlier. The average rating of the mentors was a 4.68. The mentors are listed in Table 9.

A summary of the final, overall survey is shown in Table 10. From this table, it is clear that the students are benefiting from this program. The goal of making students aware of career opportunities at the Laboratory in hopes of recruiting them upon graduation was realized. Twelve of the 15 students indicated a desire to return to the Laboratory in subsequent summers as graduate research assistants (GRAs). The other three indicated that they would also like to return, but graduate school obligations would prevent them

Table 9. Summary of Mentors

Mentor, Affiliation	Area of Expertise
Rachel Shinn, Embry Riddle Aeronautical University	Aerospace Structures
Chuck Farrar, LANL Engineering Sciences and Applications Division (ESA)-Weapons Response (WR)	Structural Health Monitoring
Norm Hunter, LANL, ESA-WR	Environmental Testing and Signal Processing
Tom Paez, Sandia National Laboratories	Random Vibrations
Matt Bement, LANL, ESA-WR	Control Systems

Table 10. Summary of Assessment Results of the Overall Program

Question	Average Rating
As a result of the program, your knowledge and experience in experimental vibrations: (5—increased a great deal, 3—increased slightly, 1—stayed the same)	4.73
As a result of the program, your knowledge and experience in analytical methods in vibrations: (5—increased a great deal, 3—increased slightly, 1—stayed the same)	4.13
Prior to the program, if you had not already decided to go to graduate school, did this program influence you to do so?	3 yes; 12 had already decided
If you had already decided to attend graduate school, did this program help reinforce that decision?	10 yes; 2 already in graduate school
Would you encourage someone to apply to the program next year?	15 yes
Would you be interested in coming back to Los Alamos National Laboratory as a graduate research assistant next summer if a position were available?	12 yes; 3 yes, but will not be able to do so
Overall rating of the summer school? (5—excellent, 4—very good, 3—good, 2—fair, 1—poor)	**4.77**

from doing so. The fact that all 15 students would encourage someone they know to apply to the program next year is clear testimony as to how positively the students viewed the program. As can be seen from Table 10, the average overall rating of the summer school was a 4.77. When the students were asked to rate the quality of the teamwork in their groups, three of the groups averaged a score of 4.27.

Selected Sound Bites. The following quotes were obtained from the final survey of the students.

- *“I really enjoyed our project; it was unlike anything I had done before.”*
- *“I am seriously considering getting my Ph.D., partly because of my experience in the summer school.”*
- *“I really enjoyed the guest lectures by the Los Alamos staff members. Many times, I thought they were better than the university lecturers.”*
- *“I loved the independence and responsibility given to students.”*
- *“…The best educational program I have ever taken part in.”*
- *“I have decided to continue my master’s degree in structural dynamics, basically because of my summer school experience. The summer school opened me to new horizons about my career and personal growth.”*

Even though the overall assessment of the program was overwhelmingly positive, there were a number of suggested improvements. The primary suggestion was, *“Make the summer school longer.”*

In the assessment of last year’s program, the students made comments concerning reordering of the lectures, changing the lecture times, and improving on the limited or mildly inadequate experimental or computer equipment. This year, students commented positively about the computer equipment but still felt that improvements needed to be made in the experimental equipment.

As in past years, the success of the program appeared to be the result of a number of factors including the following:

- the quality of the students;
- the use of projects that were relatively well defined at the beginning of the summer;
- the team nature of the projects;
- the already existing infrastructure at the Laboratory for dealing with student programs; and
- the overall quality of the mentors, distinguished lecturers, and other speakers.

Performance Goal, Objectives, and Milestones. The original performance objectives were as follows:

- The eight-week program will be designed for a select group of 15 upper-division, United States citizens, undergraduate or first-year graduate students.
- Attempts will be made to identify high-quality students from diverse (ethnic and academic) backgrounds.
- Every attempt will be made to identify students from universities that emphasize undergraduate education as well as research institutes.
- A variety of academic disciplines will be sought, including aerospace engineering, civil engineering, mechanical engineering, electrical engineering, computer science, and mathematics/statistics.
- The program will expose students to the multidisciplinary aspects of structural dynamics through an analytical/experimental research project.
- The program will develop students’ written and oral communication skills.
- The program will make students aware of career possibilities at the DOE/Defense Programs (DP) laboratories.
- Students will be required to provide written feedback regarding their experience during the summer school.

- LANL and DOE education program offices will be provided with an annual summary of the summer school and its demographics.
- The program will maintain an alumni database to track the careers of the summer school participants over the next few years. The information contained in this database will be used to quantify the success of the summer school in meeting its intended goals of motivating the students to attend graduate school and pursue engineering careers at DOE/DP laboratories. This database can be seen at the LADSS website: www.lanl.gov/projects/dss.

The milestones identified for the program in the original proposal were as follows:

1. End of November 2001: Obtain DOE funds for the FY02 summer school and begin to recruit students.
2. End of January 2002: Identify and receive commitments of guest lecturers. Obtain approval for field trips. Identify student projects and required equipment/test items.
3. End of February 2002: Host a student paper session at the IMAC. Identify students for the FY02 summer school.
4. Mid-May 2002: Obtain all necessary hardware and software for the FY02 summer school.
5. Mid-June 2002: Begin the FY02 summer school.

As summarized in the program description, all of the program objectives and milestones originally defined for this program have been met.

Even though the funding provided in FY02 was significantly less than requested, the school was kept at the same duration, and, because of the quality of the applicants, the summer school was expanded from 12 to 15 students. Additional expenses associated with the DOE funding cutback and the expansion of the summer school were paid for by LANL's ESA Division.

The guest lecturers provided oral feedback on the student projects and the students themselves. This feedback was overwhelmingly positive, and guest lecturers who have attended all three editions of the summer school said that academically, this was the best group of students that we have had.

Of particular significance was the in-kind support provided by leading software companies. MathWorks, Vibrant Technologies, and Hibbitt, Karlsson & Sorensen, Inc., provided software that would have cost more than $1 million if purchased for each student. These software donations were crucial to the success of the summer school. ESA Division provided 20 new PCs (desktop computers for students and laptop computers for data acquisition systems) for the summer school at a cost of more than $100,000. The Engineering Analysis Group in ESA provided the administrative support that was essential to the success of the summer school.

The organizers of the IMAC have set up a special session for our students to present their papers at the 2003 IMAC. ESA Division will provide financial support so that all of the summer school students can attend the IMAC.

Highlights of This Year's Accomplishments. The program appears to have achieved its primary goals of introducing a talented group of engineering students to both analytical and experimental engineering structural dynamics and of making them aware of career opportunities at national laboratories such as LANL, SNL, and Lawrence Livermore National Laboratory. Four students from the 2000 and 2001 summer schools returned to LANL this past summer as GRAs, and a fifth worked as a GRA at SNL.

This year, LANL hired its first two summer-school alumni as full-time technical staff members.

One of these new hires graduated with a master of science (MS) degree in mechanical engineering from Georgia Institute of Technology. This student had a 3.97 undergraduate GPA at Rose-Hulman Institute of Technology. For the past two years, Rose-Hulman has been ranked by U.S. News and World Report as the number-one engineering school in the U.S. without a Ph.D. program.

The other person is the first woman to be hired out of this program. This student completed her MS degree in civil engineering at the University of Southern California and had a 3.67 undergraduate GPA at Harvey Mudd College. U.S. News ranks Harvey Mudd College second to Rose-Hulman Institute of Technology in the category of engineering schools without a Ph.D. program.

A third alumnus from the 2000 summer school will be accepting a full-time staff position after she completes her MS degree in engineering mechanics at Virginia Tech this fall. This woman had a 3.94 undergraduate GPA in civil engineering at Montana State and is one of two summer school alumni who have gone on to win National Science Foundation graduate fellowships.

Clearly, the recruiting aspect of the summer school is already paying dividends. This accomplishment directly addresses the issues raised in the Chiles Commission Report regarding Recommendation #7, “Establish and Implement Plans on a Priority Basis for Replenishing Essential Technical Workforce Needs in Critical Skills.”

The students in the class of 2002 rated the summer school as excellent, and every student indicated he/she would encourage someone he/she knows to apply to the summer school. All the student groups produced quality papers that will be presented at the IMAC. A culminating highlight of the summer school was the oral presentations that the students made to the staff in the ESA Division. As with the past two summer schools, the managers in this division noted that the student presentations were of the quality that the staff would give for a high-level program review in the Weapons Engineering and Manufacturing Directorate. The students’ conference papers, along with their viewgraphs, can be viewed at www.lanl.gov/projects/dss.

Finally, with regard to facilities and equipment, a significant accomplishment this past year was the acquisition of a permanent building to house the summer school. This building was completely remodeled and refurnished before the 2002 session. Additional Laboratory space was acquired, and experimental equipment was purchased by ESA Division so that each research group had all the experimental equipment necessary to carry out its project.

References

1. *Engineering & Technology Degrees, 1999*, Engineering Workforce Commission of the American Association of Engineering Societies (EWC/AAES), 1999.

Materials Science Technician Training Program

Program Description. The 2002 Materials Science Technician Training Program was a continuation of the very successful pilot program begun in 2001. Before the institution of this training program, there was no proactive recruitment, training, or retention plan for these specialized technicians available in the region.

At present, 73.9% of the materials science technicians at Los Alamos National Laboratory (LANL, the Laboratory) are 40 or older. It is therefore essential that the Laboratory establish and maintain a pipeline for future materials science technicians and see to it that the knowledge accumulated by current technicians is preserved and passed on to the next generation. The need for such technicians is critical and growing. It is expected to be much greater when the Laboratory's new Center for Integrated Nanotechnologies is completed.

The Materials Science Technician Training Program is open to U.S. citizens with a high school diploma or general educational development certificate (GED). It consists of an internship (full-time, limited-term hire) at the Laboratory in a division that employs materials science technicians—such as the Materials Science and Technology Division (MST) (see Figure 16), the Engineering Sciences and Applications Division (ESA), and the Nuclear Materials and Technology Division (NMT). Each

Figure 16. Students survey the types of materials that they will be testing at the Structure/Property Relations Group (MST-8) mechanical testing laboratory. To save money, tests are done on miniature specimens. One test involved placing a threaded cylinder in a machine and pulling to test its tensile strength. MST-8 provides the Laboratory with electron microscopy, ion microprobe, and ion implantation facilities. The group also possesses expertise in x-ray and neutron scattering, synchrotron x-ray studies, and scanning probe microscopies.

intern works closely with a researcher/mentor and his/her team in a Laboratory setting.

Northern New Mexico residents who are at an entry-level point in their careers and who are technically competent are prime candidates for this program and have been recruited heavily and accepted warmly. At this time, four program participants have been hired at the Laboratory, and six program participants are in the process of being matched with mentors/supervisors.

The interns who have been hired were given release time, starting in August, from their technician duties to attend classes at the University of New Mexico at Los Alamos (UNM-LA). A certificate in materials science technology (36 credits) and an associate of arts degree in pre-engineering with a concentration in materials science (79 credits) are available at UNM-LA. Figure 17 shows a student creating models of crystal lattices during a class at UNM-LA. Three of the materials science courses developed for this program also allow for transfer of credit to the New Mexico Institute of Mining and Technology, currently the only New Mexico university offering a bachelor-of-science or master-of-science degree in metallurgical and materials engineering.

Materials science technicians play an important role in the ability of the Laboratory to fulfill its mission—to ensure the safety and reliability of the U.S. nuclear weapons stockpile; to reduce threats to U.S. security; to use science to clean up the legacy of the Cold War; and to provide technical solutions to key energy, environmental, infrastructure, and health security problems. In order to support these efforts, new materials science technicians must be recruited.

The Materials Science Technician Training Program, which offers full-time work with benefits, targets regional high school graduates who possess valuable skills but who do not wish to attend college or cannot afford to attend full time. In addition, the education and training included in this program improves retention rates, productivity, efficiency, flexibility, and morale of the technician trainees. Scientists/supervisors benefit from a technician who can contribute quickly, who is engaged in a specialized materials science educational program, and who is not paid from research funding.

The program has succeeded in part because it is supported by MST leaders and by scientists who are intimately aware of the current need and imminent dire shortage of trained, skilled, educated materials science technicians. It is less costly to recruit, train, and retain regional program participants than to import trained or untrained technicians from outside the area—a fact that makes the program financially attractive to the participating divisions.

Figure 17. A student uses ping-pong balls to create models of crystal lattices.

Performance Goal, Objectives, and Milestones. The goal of this program is to establish and maintain in northern New Mexico a source of well-trained materials science technicians for the Laboratory. The objectives (and measurable criteria) supporting this goal are as follows:

- Establish excellent and relevant course content for two upper-level materials science courses (MST 108T, Introduction to Mechanical Behavior of Materials, and MST 110T, Materials and Process Selection) currently included in the UNM accredited curriculum for the Materials Technology Certificate Program. Students at UNM-LA are shown in Figure 18.

Criteria: Use video courses available through professional societies; use course materials available on the website of the Materials Science and Engineering Department, Ohio State University; tap into the curriculum-development expertise of materials scientists at the Laboratory who have experience teaching at the college level.

Figure 18. Students gather around specialized equipment in a classroom at UNM-LA.

- Hire materials science technician trainees at the Laboratory.

  Criteria: Recruit and enroll 10 students for the UNM-LA Materials Technology Certificate Program in August 2003. Hire 10 technician interns at the Laboratory in August 2003. By the summer of 2004, make available eight to ten Materials Science Technician Training Program graduates as Laboratory employees. By the summer of 2005, provide another 10 program graduates as potential full-time Laboratory technician hires.

- Use current Laboratory materials science technicians to monitor first-year students. Second-year students and technicians will mentor first-year students.

  Criteria: Evaluations will be completed and become part of an ever-expanding statistical database. Evaluations will be provided to the mentor/supervisor to allow for continuous quality improvement in the mentoring provided.

- Institutionalize the program at a level higher than the division level so that scientists and materials science technicians in NMT and ESA can participate.

Milestones To Be Achieved. The Laboratory is seeking to achieve the following milestones:

- Fund the program for 10 hires per year at a level higher than the division level.
- Hire at least one participant/technician trainee for NMT or ESA.

Relationship of the Program to the Laboratory Mission and Goals. By creating a means to recruit, hire, and retain a highly trained and highly educated materials science technician workforce, this program contributes to the Laboratory's mission of ensuring the safety and reliability of the U.S. nuclear weapons stockpile, reducing threats to U.S. security, using science to clean up the legacy of the Cold War, and providing technical solutions to key energy, environmental, infrastructure, and health security problems. Such technicians contribute directly to ensuring that the Laboratory has a workforce that is competently trained in Department of Energy/Defense Programs critical skills area #4: materials science and technology.

Highlights of This Year's Accomplishments. The two-year curriculum was designed to incorporate courses such as chemistry, algebra, and trigonometry that provide a foundation for understanding materials science and technology concepts. Two courses in "Introduction to Materials Science" set the stage for the four specialty materials science courses, which, in turn, provide a deeper comprehension of the structure, properties, processing, and performance relationships that materials exhibit.

The "Materials and Process Selection" course is currently being developed by a Laboratory technical staff member who has taught a similar course in the past. This course will provide an opportunity for Laboratory mentors/scientists to assign their interns to the task of designing a material or process that is needed in the workplace. The "Introduction to Mechanical Behavior of Materials" course is currently being developed as well.

The "Introduction to Microscopy and Microstructures" and "Principles of Heat Treating" courses are being taught this semester to six second-year technician interns.

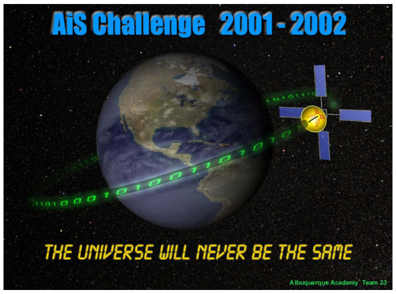
Salary Structure and Release Time. Program participants hired in 2002 are paid in accordance with the Laboratory's student salary scale. The students are hired as full-time, limited-term University of California employees and are given up to 10 hours per week release time to attend classes at UNM-LA.

Recruiting and Hiring. During the summer of 2002, information about the technician-training program was disseminated both formally (through student orientations, job fairs, and career offices at regional high school and college campuses and by means of a brochure and other Laboratory publications) and informally (through personal e-mail and word of mouth). Information about the training program is kept on file at the Laboratory's Diversity Office, the Human Relations Division Hiring Group, the Educational Program Office, and the MST, ESA, and NMT Division Offices.

Recruitment of scientist supervisors/mentors was accomplished through MST mailings and personal phone calls.

As a result of the recruitment and subsequent screening of applicants, 11 students were recruited and enrolled in the "Introduction to Materials Science I" course in August 2002. Of these 11 enrollees, four have been hired in MST, one works in NMT, one is currently enrolled in a local high school, and five are being interviewed for intern positions at the Laboratory. Two of the four students hired in MST are working in the Metallurgy Group (MST-6), and two are working in the Polymers and Coatings Group (MST-7).

Clearances for Program Participants. Four of the six program participants hired in 2001 have applied for a Q clearance. These four technician interns are working in uncleared areas until they receive their clearances. When their clearances are activated, these technician interns will be assigned to a mentor/supervisor in a cleared area.



New Mexico High School Adventures in Supercomputing Challenge

Program Description. The New Mexico High School Adventures in Supercomputing Challenge (AiS, the Challenge) is a two-fold educational program. Primarily, it is an academic-year-long program in which teams of middle school or high school students conduct computational science projects using high-performance computers. Secondly, during the summer, it is a computational science-and-technology training program for teachers.

Los Alamos National Laboratory (LANL, the Laboratory) has been a major sponsor of the Challenge since 1990, when the Laboratory helped begin the program. The Laboratory saw the need to interest students in science-related disciplines and saw the program as a way to help improve the education of students in northern New Mexico. It also saw the Challenge as a way to give something back to the surrounding communities and create a very positive Laboratory outreach program.

Recruitment for each Challenge year is accomplished by word of mouth (12 years of success with students); through visits to schools by AiS program directors and other Laboratory staff members; through talks at various workshops and conferences; and by means of the AiS Challenge website and e-mail invitations to several school-related mailing lists, including the list for the Regional Educational Technology Assistance Program.

The Challenge recruits teams of students to complete science projects using high-performance supercomputers. Each team of one to five students and a sponsoring teacher defines and works on a single computational project of its own choosing, using the New Mexico Technet, Inc., (NM Technet) network to connect to the supercomputers at LANL, Sandia National Laboratories (SNL), Maui High Performance Computing Center, the University of New Mexico, and New Mexico State University. Throughout the program, project advisors and the Challenge organizers and sponsors provide help and support to the teams.

All teams present their projects at the Awards Expo at the Laboratory in April. Judges evaluate the projects, displays, and presentations. There are many awards of savings bonds and scholarships for individuals and computer equipment for schools (see Figure 19). All of the participants go home as winners because of the Challenge experience.

After presenting their projects, teams take tours of the Laboratory to see the latest high-performance computers, listen to talks by scientists on current research, and participate in demonstrations of Laboratory science and how it serves society.

Figure 19. Brian Rosen, left, Robert Cordwell, holding plaque, and their teacher, Stephen Schum, right, of Albuquerque's Manzano High School, took second place in the 12th annual New Mexico High School Adventures in Science Supercomputing Challenge.

The program originally targeted high school students, but several years ago, Senator Jeff Bingaman suggested that middle schools be allowed to participate. Four middle schools were encouraged to participate in fiscal year 2002 (FY02). One middle-school team made the finals and received the Judges' Special Recognition Award. As a result, the words "high school" will be dropped from the name in 2003, and the program will become the "New Mexico Adventures in Supercomputing Challenge."

This fall, the Challenge will begin its 13th year. During the past 12 years, more than 5,500 students have participated.

Participants who complete their degrees and seek permanent employment at the Laboratory are closely tracked and documented. Recent analysis of the Laboratory's Employee Information System showed that 62 past AiS participants are now active employees.

The AiS Challenge has had a positive impact on students, teachers, schools, and communities throughout New Mexico. As a result, the Laboratory's participation has had a positive effect on participants' perceptions of the Laboratory. In addition, the Laboratory has been able to use the AiS Challenge to promote good-neighbor practices and has received a lot of positive press coverage because of the Challenge.

The primary sponsors of AiS are the Department of Energy (DOE)/Defense Programs (DP) Office of University Partnerships; the National Aeronautics and Space Administration (NASA)-Ames; the Defense Advanced Research Projects Agency (DARPA); Hewlett Packard (HP); NM Technet; and the Laboratory.

(Current details about the AiS Challenge can be found at http://www.challenge.nm.org.)

Performance Goal, Objectives, and Milestones. The primary goal of the Challenge is to build the Laboratory's pipeline of computer talent by improving students' understanding of computational science. The program met this goal in FY02 by exposing more than 400 students and teachers to computational experiences, promoting careers in science and engineering, providing access to high-performance computers, instituting electronic networking among schools, and connecting students and technical staff members at the Laboratory.

The Challenge strives to attract underrepresented groups of New Mexicans because they form the population most likely to want to stay in the area—an important consideration for the Laboratory and other employers hoping to maintain a stable scientific and technical workforce.

The Laboratory reaches out to underrepresented groups by making school visits to rural schools, by encouraging new teachers to participate in the Summer Teacher Institute, and by promoting gender equity and diversity in discussions with teachers. Figure 20 displays ethnicity among Challenge students in pie chart form.

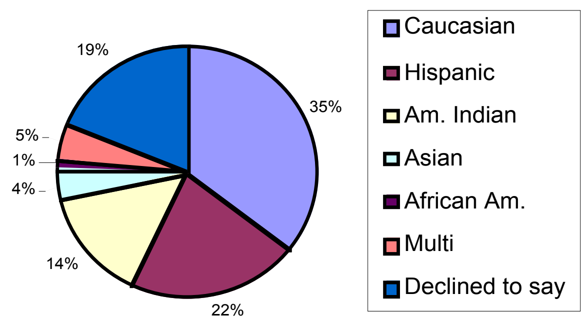


Figure 20. Ethnicity of Challenge students.

The DOE/DP Advanced Simulations Computing Campaigns need individuals who are familiar with programming high-performance computers. Computational science is fundamentally important to the Stockpile Stewardship Program. Laboratory scientists, working on the Accelerated Strategic Computing Initiative (ASCI) Blue Mountain Supercomputer, use parallel-programming techniques for modeling the safety, reliability, and performance of nuclear weapons.

In the past five years, Challenge students have used the same parallel programming techniques (specifically the Message-Passing Interface) on a cluster of Silicon Graphics, Inc., Origin 2000 computers that the Laboratory named Theta. Theta has the same architecture as the ASCI Blue Mountain Supercomputer (see Figure 21).

Figure 21. View of the ASCI Bluemountain Supercomputer.

In effect, we are training individuals in the type of work that is necessary to assist in effectively carrying out our Stockpile Stewardship Program.

Though not all AiS Challenge projects need the power of a high-performance computer, all of the computer programs of winning projects for the last several years have been run on high-performance computers.

Highlights of This Year's Accomplishments. During FY02, the former New Mexico High School Supercomputing Challenge merged with the former Adventures in Supercomputing program to become the New Mexico High School Adventures in Supercomputing Challenge.

By all accounts, 2002 was a successful year. It began with the twelfth annual Kickoff Conference at Glorieta, for which more than 400 students and 56 teachers registered. Thirteen Laboratory employees were among the 27 staff members who taught classes and discussed team projects with students. The keynote speaker was Sandra Begay-Campbell, a Native American who is a civil engineer at SNL.

FY02 Challenge statistics illustrate the program's success: 109 team abstracts were submitted; 76 team interim reports were filed; 54 teams presented their projects to a set of judges at the February project evaluations on Saturdays at institutions around the state; and 48 teams submitted written final reports.

Thirty judges selected six teams as finalists (see Figure 22). The selections were based on final reports. Another six teams were selected as finalists at the Awards Expo where they presented their projects to a group of three judges. The AiS first- and second-place teams and 10 honorable-mention teams were selected from among these 12 teams. Awards were presented the next day. Finalists during the awards ceremony are shown in Figure 23.

Figure 22. Judges after dinner and a long night of discussing and deciding who would receive what rewards.

Scholarships worth $28,000 were awarded at the year-end awards ceremony. In addition, the Laboratory found new sponsors so that gift certificates could be awarded to all of the honorable-mention teams. SNL offered a tour of its facilities to AiS Challenge participants in March 2002.

Recruitment and retention strategies were enhanced through the addition of a recruitment function to the student-tracking database, and the AiS website was modified to include information about Critical Skills Development Program

Figure 23. The 2001–2002 finalists on stage during the awards ceremony.

opportunities. The website now includes profiles of former Challenge students who have been hired as technical staff members at the Laboratory. In December, the Laboratory sent letters to all past finalists, encouraging them to apply for summer positions at both LANL and SNL. The Laboratory is now in the process of contacting those students to determine how many were successful in finding positions.

Summer Teacher Institute. The Summer Teacher Institute (STI, the Institute) is a two-week institute for teachers sponsored by NASA-Ames in conjunction with San Juan College, LANL/DOE, DARPA, and NM Technet. The Institute is used as a means to recruit new schools into the Challenge, encouraging institute participants to return to their schools and champion the Challenge. The logo for STI is shown in Figure 24.

Figure 24. Summer Teacher Institute logo.

Acquiring skills to support computational science for middle school and high school students is the overarching goal of STI. Topics covered in the most recent Institute included problem solving, science, math modeling, technology, programming, research, working with mentors, project management, time management, team management, presentations, gender equity, computer ethics, and technical writing.

Participants were provided with room and board, and a stipend was awarded at the end of the Institute. Participants earned three units of graduate credit from the New Mexico Institute of Mining and Technology. The participants expressed positive feelings about being treated as professionals.

AiS Challenge sponsor HP provided laptop computers to each participant. During the Institute, the participants learned how to use the laptops and loaded several software packages onto them to aid in the work on their projects.

Three textbooks were provided to everyone: a C++ text, a Java text, and an HTML text. Several handouts and some software were also provided.

The same test, using questions about the subject areas covered in the Institute, was given on the first day and the last day of the Institute. Pretest and posttest scores showed that the participants gained in subject knowledge during the Institute (see Figure 25).

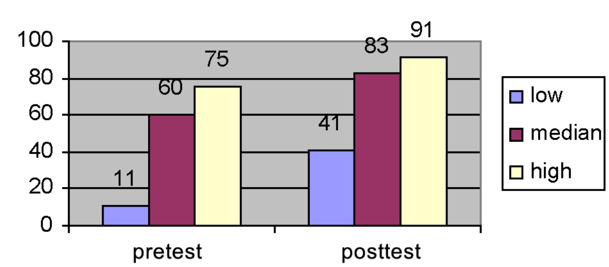


Figure 25. Teachers' pretest/posttest scores chart.

The participants were grouped into four teams. Each team developed a project and worked on it for the entire two weeks of the Institute. Team members had to do research, programming, technical writing, and presentations. They experienced—in a condensed format—just what teams go through during the AiS Challenge year. They learned the importance of teamwork to a successful project, discovering that team members have different strengths and that all of those strengths are needed.

Evaluation forms drew comments about how well the mini-Challenge project prepared students for working with their teams by teaching them what will be expected, the importance of a concise problem statement, and the need for good time management.

Students came from the following schools: Ernie Pyle Middle School, Eldorado High School, and Bosque School in Albuquerque; Mesa Alta Junior High School and Bloomfield High School in Bloomfield; Tohatchi High School; Shiprock High School; Aztec High School; Yucca Junior High School in Clovis; Melrose High School; and Alamogordo High School.

Interaction with Other Programs. The Siemens Foundation has joined the list of Challenge sponsors, and a representative from Siemens visited Challenge events. Siemens hopes to encourage AiS Challenge teams to submit their projects to the Siemens Westinghouse Competition in Math, Science & Technology, which has top awards of $100,000.

NASA-Goddard is interested in creating a program similar to the AiS Challenge in the Baltimore, Maryland area. A representative attended the Awards Expo and was encouraged and excited about what he experienced.

Nuclear Science Education for the 21st Century: Glenn T. Seaborg Summer Fellowship Program

Program Description. This program continues a unique undergraduate/graduate-level research experience, which is focused on the fundamental chemistry of weapons science. Coordinated through the Glenn T. Seaborg Institute for Transactinium Science (ITS), this year's program featured selective research fellowships in *f*-element chemistry, nuclear and radiochemistry, and high explosives chemistry and physics.

The 10- to 14-week research fellowships in fiscal year 2002 (FY02) consisted of careful student-mentor pairings and independent laboratory research. Among the fellows were both undergraduate students at the junior and senior levels and graduate students at all levels. The students were recruited from more than 100 universities (with graduate programs) through poster mailings and an individual e-mail campaign. Efforts were made to recruit past graduate participants in order to provide a mentorship educational experience.

In addition to the fellowships, a volunteer effort by staff members at Los Alamos National Laboratory (the Laboratory) supplemented the research fellowships with a 12-week Seaborg Institute Educational Lecture Series (SIELS). The lectures provided an introduction to the scientific underpinnings of the research areas listed previously—topics frequently overlooked in most undergraduate and graduate courses.

Performance Goal, Objectives, and Milestones. Our aim is to continue development of an internationally recognized educational program that will (1) act as a national resource for the teaching of weapons sciences, (2) provide a vehicle for early recruitment of the next generation of nuclear and weapons scientists and engineers, and (3) offer accredited courses that can expedite a student's graduation.

Because of the success from the previous years, this program was continued and grew to include new areas—for example, general weapons technologies and dynamic experimentation. We are hopeful that this growth will continue and will lead to the establishment of a number of similar educational programs in related disciplines such as materials, metallurgy, and interfacial and environmental aspects of actinide science.

At the conclusion of the program, the students had acquired a greater appreciation of the diverse role of actinide, nuclear, high explosives, and radiochemistry in nuclear energy and national security. We believe that this appreciation, together with the program's introduction to the extensive research facilities available at the national laboratories, can nudge talented young researchers toward careers in actinide, nuclear, and weapons science. All previous milestones listed in our proposals—including the fellows search, and research presentations and publications—were realized in FY02, and we are continuing this trend in the current fiscal year. In addition, we are continuing to expand and adapt the program to reach larger groups of students.

A combined total of 219 students have registered for our workshops, summer courses, and research fellowships. In addition to students enrolled at the University of New Mexico at Los Alamos (UNM-LA) campus, the program drew students from several other locations. Distance-education sites coordinated through the UNM and Waste-Management Education and Research Consortium (WERC) systems led to the registration of students from UNM's Albuquerque campus, from the New Mexico Institute of Mining and Technology in Socorro, and from the Carlsbad Field Office of the Department of Energy (DOE).

The program attracts a diverse audience representing a number of ethnic and minority groups. During the four years that this program has been in operation, 97 students and fellows have been women—45% of total enrollment. We are extremely pleased with the relatively high proportion of female undergraduate and graduate students, technicians, and postdoctoral students who have signed up, and we will strive to maintain this level of interest.

Highlights of This Year's Accomplishments. We detail below our progress in FY02 on three projects, (1) sponsoring of research fellows in actinide and weapons science during the summer of 2002, (2) extension of the educational program to new areas of the Defense Programs (DP) mission, and (3) maintaining high external visibility for students, science, and the program. The program drew participation by 13 students and six university professors in FY02. A number of fruitful collaborations between university faculty members and staff members at the Laboratory were initiated, and further sharing of students and resources is growing.

- Arrangements were made to present the "Modern f-element Chemistry" and the "Nuclear and Radiochemistry" courses at the UNM-LA campus, and the courses were added to the spring and summer schedule as course numbers Chem 325 (undergraduate) and Chem 537 (graduate). We also sought collaboration with the broadcasting personnel at the WERC site at New Mexico State University, hoping that a rebroadcast of the signal by satellite could be sent to downlink sites around the country. Unfortunately, these unclassified courses had to be cancelled because of concerns raised by DOE post-9/11.
- In January 2002, we distributed posters to approximately 125 chemistry departments nationwide announcing our intention to fund 10 Seaborg Institute Research Fellows during the summer of 2002. We updated and maintained our website (http://pearl1.lanl.gov/seaborg) to provide information about the Seaborg Institute and its educational programs and to allow fellowship applicants to apply online. The deadline for applications was March 1. We selected 13 students: five senior undergraduates, one junior undergraduate, and seven graduate students. The majority of the fellows were at the Laboratory for 10 to 12 weeks starting in May 2002. Four of the fellows extended their stays and will be returning on a regular basis to perform research at the Laboratory. They attended the SIELS in addition to performing independent research under the guidance of Laboratory scientists. During their summer research, they gave oral presentations of their work to groups of staff members, postdoctoral employees, and fellow students. Tours and demonstrations of the Plutonium Processing Facility and the Explosives Testing Yard are also usually part of the summer experience, but because of the post-9/11 response, these activities could not be held.
- In an attempt to broaden our program and maintain its educational integrity, Laboratory staff members from the Chemistry (C), Nuclear Materials Technology (NMT), Materials Science and Technology (MST), and Dynamic Experimentation (DX) Divisions volunteered to give a series of unclassified lectures. These three-hour lectures were given over 12 weeks and involved topics in actinide and lanthanide chemistry, nuclear and radiochemistry, and explosives science. These lectures were open to the entire Laboratory community and had an average attendance of 60 people, ranging from undergraduate students to members of upper Laboratory management.
- Several of our fellows have been recipients of prestigious awards or fellowships. Amanda Bean was accepted to attend the 2002 Nobel Laureate Meeting in Lindau, Germany. Piyush Shukla received the Dorothy Banks Fellowship in the Department of Chemistry and

Biochemistry at the University of Texas at Austin (UT-Austin) in the fall of 2002. Their research efforts have also resulted in presentations at national meetings and publications in high-profile, peer-reviewed journals.

Because we wanted to continue improving the quality of the program, we have sought feedback and continued contact from students. We compiled a list of the e-mail addresses of all students participating in the courses so that we could track their future education or employment. We had four research fellows during our first year, 1999—two undergraduates and two graduate students. All four of these students have pursued careers in nuclear science. One student is now a radiochemist at the National Institutes of Health (NIH). One of the FY02 fellows, an undergraduate, has now become a full-time graduate research assistant, and four of the graduate students will be returning to the Laboratory on a regular basis to continue their independent research. We are extremely encouraged by these positive results, especially because all of the students have indicated that their experience with this program has guided their current pursuits in nuclear science.

The research fellows from the summer of 2002 all had an extremely productive time at the Laboratory. Their names (shown in boldface print below) appear on seven manuscripts that have been published, submitted for publication, submitted as part of patent applications, or included in professional proceedings in this fiscal year under the following titles:

- "Dialkyl Aluminum Amides: New Reagents for the Conversion of C=O into C=NR Functionalities," by J. C. Gordon, **P. Shukla**, A. H. Cowley, J. N. Jones, D. W. Keogh, and B. L. Scott. Accepted for publication by *Chemical Communications*.
- "Synthesis of Nanoscale Tungsten Trioxide," by **C. Bulian**, R. Dye, S. Son, B. Jorgensen, and J. Busse. Patent application in progress; submitted in 2002.
- "High-Nitrogen Explosives," by D. L. Naud, M. A. Hiskey, J. F. Kramer, R. Bishop, H. Harry, S. F. Son, **C. Bolme**, and G. Sullivan. Appeared in the *Proceedings of the International Pyrotechnics Society, The Twenty-Ninth International Pyrotechnics Seminar*, pp. 699–710, Westminster, Colorado, July 14–19, 2002.
- "Propagation of Metastable Intermolecular Composites (MIC)," by S. F. Son, J. R. Busse, B. W. Asay, P. D. Peterson, J. T. Mang, **B. Bockmon**, and M. Pantoya. Appeared in the *Proceedings of the International Pyrotechnics Society, The Twenty-Ninth International Pyrotechnics Seminar*, pp. 203–212, Westminster, Colorado, July 14–19, 2002.
- "Combustion Performance of Metastable Intermolecular Composites (MIC)," by **B. Bockmon**, S. F. Son, B. W. Asay, J. R. Busse, P. D. Peterson, J. T. Mang, and M. Pantoya. Appeared in the *38th Combustion Subcommittee Proceedings, Journal of Aerospace and Defense Industry News*, Destin, Florida, April 4–8, 2002.
- "Reaction Propagation Physics of Al/MoO_3 Nanocomposite Thermites," by S. F. Son, B. W. Asay, J. R. Busse, B. S. Jorgensen, **B. Bockmon**, and M. Pantoya. Appeared in the *Proceedings of the International Pyrotechnics Society, The Twenty-Eighth International Pyrotechnics Seminar*, Adelaide, Australia, November 4–9, 2001.
- "Characterization of the Interactions Between Neptunyl and Plutonyl Cations and Expanded Porphyrins," by Jonathan L. Sessler, **Anne E.V. Gorden**, Daniel Seidel, Sharon Hannah, Vincent Lynch, Pamela L. Gordon, Robert J. Donohoe, C. Drew Tait, and D. Webster Keogh. In press at *Inorganica Chimica Acta*.

Student and Postdoctoral Development. We will be distributing an announcement for the future courses and workshops to students and postdoctoral researchers who worked within the C, NMT, MST, or DX Divisions at the Laboratory. The announcements will be posted on both the Laboratory's student web pages and postdoctoral web pages so that they will be available to all incoming students. We have previously had extremely positive responses to the course announcements from many Laboratory employees, and a significant number have registered to take a course.

The 13 research fellows (one shown in Figure 26) who worked at the Laboratory under the program this fiscal year (and their areas of research) were as follows:

Amanda Bean, a graduate student at Auburn University. Amanda's mentor for the summer was Wolfgang Runde (Isotope and Nuclear Chemistry Group, C Division). Amanda worked on the synthesis of new americium (Am) compounds with oxoanionic ligands—oxalate and iodate.

Hydrothermal synthesis has been developed in the labs at Technical Area (TA)-48 for the successful preparation of neptunium and plutonium oxalate and iodate. However, this technique has never been applied to americium coordination compounds. Although structural information on about 35 americium compounds is reported in the literature, information on the coordination and bonding of oxoanions with americium remains rare. Most of the structural information is derived from x-ray diffraction powder data, and only a handful of characterized single crystals have been reported.

As starting material, aliquots of AmO_2 dissolved in 3 M HCl, and KIO_4 obtained from Aldrich (without recrystallization) were placed in an autoclave, and the mixture was reacted at 180˚C for 72 hours. Small yellow-golden crystals were obtained and structurally characterized by x-ray diffraction. The analysis revealed anhydrous Am(III) iodate, $Am(IO_3)_3$, which is isostructural to the Gd(III) compound $Gd(IO_3)_3$. Eight triangular iodate pyramids and Am^{3+} ions located within a distorted $[AmO_8]$ dodecahedron form a three-dimensional network with Am-O bond distances ranging between 2.34 and 2.60 Å and averaged I-O distances of 1.80 Å (see Figures 27 and 28).

Figure 26. Patricia Melfi of UT-Austin transfers Np(VI) with her mentors, Pam Gordon and C. Drew Tait.

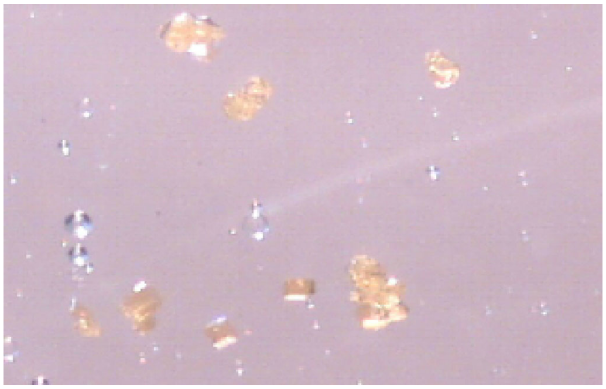


Figure 27. $Am(IO_3)_3$ single crystals.

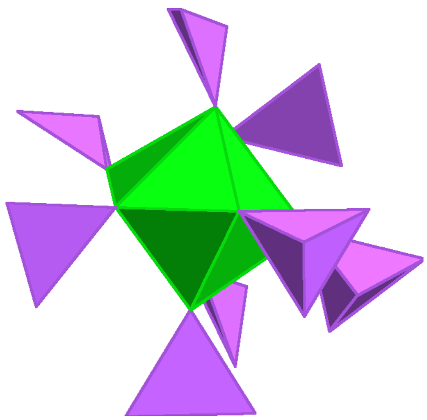


Figure 28. Coordination polyhedra in $Am(IO_3)_3$.

This analysis constitutes only the fourth structural characterization of an Am(III) compound with an oxoanion as ligand. Attempts to synthesize the first Am(VI) single crystals failed, probably because of the instability of the hexavalent oxidation state of americium.

Bryan Bockman, a graduate student at Texas Tech. Bryan is a returning student in this program. His mentor for the summer was Steve Son of the High Explosives Science and Technology Group (DX-2). Bryan looked at the propagation physics of metastable intermolecular composites (MIC). He used various experiments to determine the mechanism involved in the reaction of these nanoscale thermites. The results were presented at three conferences, and we are preparing an invited chapter in an American Chemical Society (ACS) book. During the summer, he developed an instrumented burn tube to examine the combustion of these materials. Pressure and light were measured at points along the tube, and the burns were captured with high-speed video. The figures below show a sample of the results obtained. The first figure shows the experimental setup for the instrumented burn tube (see Figures 29, 30, and 31).

Cynthia Bolme, a junior at the University of California-San Diego (UC-San Diego). Cynthia worked in DX-2. Her mentor for the summer was also Steve Son. Their work focused on measuring

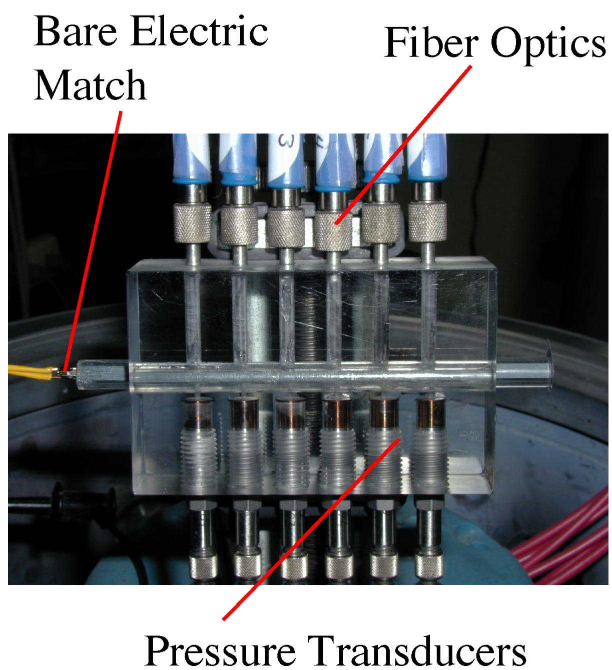


Figure 29. Experimental setup for the instrumented burn tube.

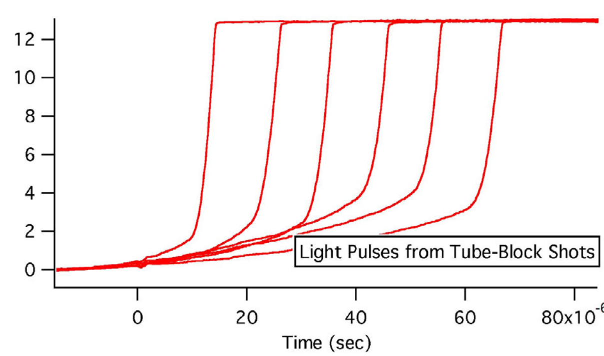


Figure 30. Fiber-optic light traces.

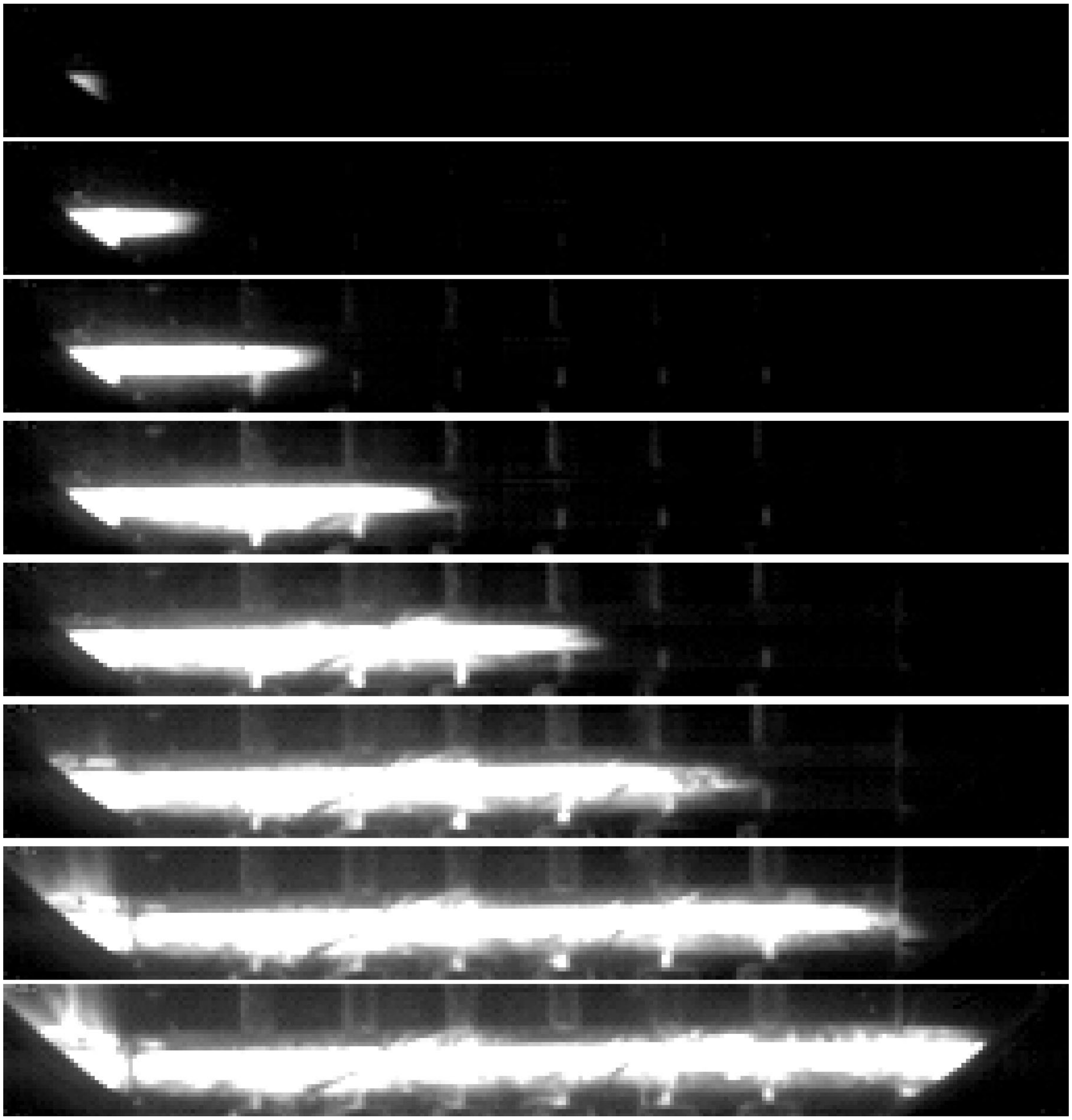
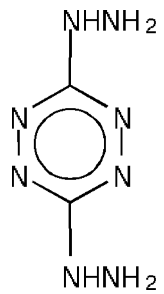


Figure 31. Images obtained from the instrumented tube experiment. The time between frames shown is 16 microseconds.

the pressure dependence on the deflagration rates of high explosives. In FY01, Cynthia developed and performed experiments to examine reaction violence in explosives. This year (FY02), she examined the use of high-nitrogen explosives as enhanced blast explosives. These demonstration experiments led, in part, to significant new homeland defense funding from the Defense Threat Reduction Agency. DHT (di-hydrazino-tetrazine) is a pure fuel, yet it can detonate or burn without an oxidizer. Because it is a high hydrogen material, the products are very reactive and, potentially, can be used in an enhanced blast/FAE (fuel/air explosives) application. The chemical structure of DHT is shown in Figure 32. A sample of the data obtained is shown in Figure 33. In FY02, Cynthia also continued to make burning rate measurements as a function of pressure of novel high-nitrogen materials as a function of pressure. This work contributes to a Laboratory Directed Research and Development project on high-nitrogen propellants.



Di-hydrazino-tetrazine

Figure 32. The chemical structure of DHT.

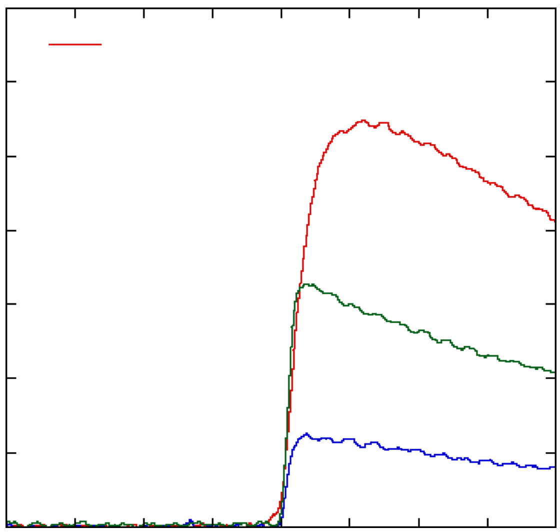


Figure 33. The enhanced blast effect of DHT with MIC in a two-liter vessel.

Christopher Bulian, South Dakota School of Mines and Technology. Christopher's mentor for the summer was Steve Son. Christopher was a new student in the program this year. He also studied MIC materials and focused on making very high-density energetic materials. Because of the high vapor pressure of tungsten metal, typical vapor deposition and plasma synthesis methods used to produce nanoscale powders would likely prove to be both difficult and expensive. To avoid the issue of having to vaporize a precursor to tungsten trioxide, the research became focused on finding a precursor that could be dissolved into solution and then "crash" precipitated out to prevent large crystal growth and, theoretically, to produce nanoscale particles of tungsten trioxide. The relatively cheap cost of the precursor and the scalability of such a process also provides promise. Christopher was able to make very good quality nanoscale tungsten oxide that can be used in MIC material.

Scanning electron microscope (SEM) imaging of the nanoscale tungsten trioxide powder showed an interesting shape to the particles. Most ultrafine powders consist of particles that are roughly spherical in shape. The WO_3 particles, however, are sheetlike in appearance (see Figure 34.) It can be seen from the image that the sheetlike particles are approximately 10 nm or less in thickness and have a length and width not generally exceeding 100 nm.

Intermixing of the particles with nanoscale aluminum provides a good composite material for thermite applications. By way of a simple wet chemistry method of dissolving ammonium paratungstate into solution and "crash" precipitating the tungsten trioxide species by rapid shifting of the chemical equilibrium, we have developed an effective and scalable process for production of tungsten trioxide nanopowder. SEM imaging has shown the powder to have uniform particles and a good particle size distribution. BET (Brunauer-Emmett-Teller) analysis shows that the bulk powder has a specific surface area of 156.3 m^2/g.

Using isopropanol as a medium, we have also developed an effective procedure to intermix the tungsten trioxide particles with aluminum. Burn tests using the MIC composite have shown not only that it can react just as well if not better than the molybdenum trioxide MIC, but also that there is less particulate residue remaining after the reaction has occurred. Future investigation is already under way to clarify its reactive properties and tailor different compositions for various uses in both industrial and military applications.

The synthesis process of tungsten trioxide is being scaled up to a steady-state flow process for mass production. A patent disclosure and paper are in progress. Christopher plans to return next year, and his Master of Science degree work will include this research.

Christin Carlson, graduate student, Vanderbilt University. Christin's mentor for the summer was Kevin John of the Actinide, Catalysis, and Separations Chemistry Group in C Division (C-SIC). Christin came to Los Alamos interested in extending the chemistry of bulky allyl ligands (developed under the direction of her graduate

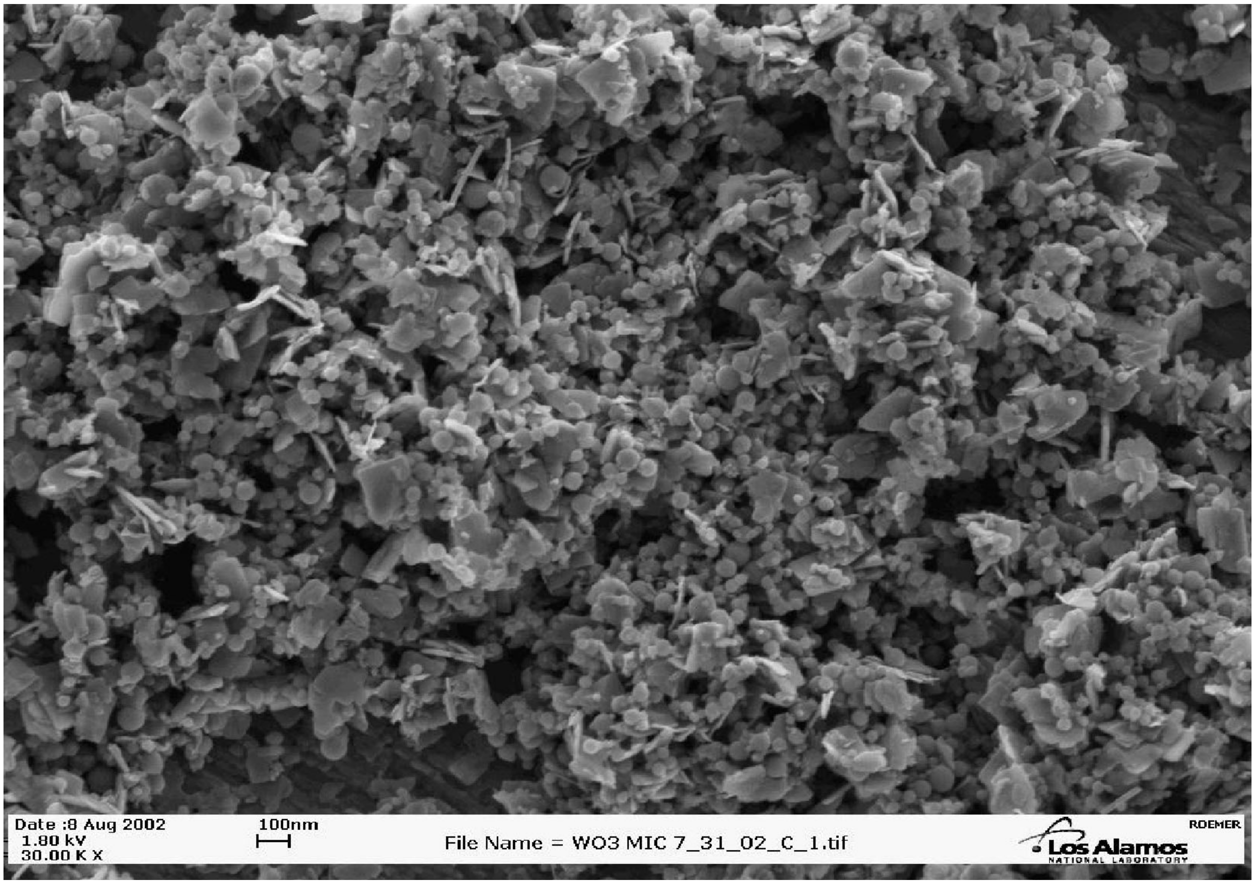


Figure 34. SEM image of an intermixed composite of aluminum with tungsten trioxide.

advisor, Timothy Hanusa at Vanderbilt) to lanthanides. She was instrumental in expanding the scope of efforts already under way in investigating the reactivity of (nonradioactive) lanthanides with a variety of 1,3-disubstituted allyl ligands. She prepared and characterized—using nuclear magnetic resonance (NMR) and infrared (IR) spectroscopies as well as single crystal x-ray diffraction—several complexes of the type $[La(\pi\text{-}1,3\text{-}(SiMe_3)_2\text{-}C_3H_3)_3I]^+$. She presented a poster on this work at Symposium 2002 at the Laboratory and won the "best chemistry" poster prize, for which she received an award and got to meet Laboratory Director John Browne.

Some of this work was also presented at the Boston ACS meeting in August 2002 by Cris Kuehl (a postdoctoral researcher in John's group who worked with Christin on several aspects of the project). She also began a project focused on the reactivity of these ligands with rhodium/iridium (Rh/Ir) and prepared the novel complex $M(\pi\text{-}1,3\text{-}(SiMe_3)_2\text{-}C_3H_3)_2(\sigma\text{-}1,3\text{-}(SiMe_3)_2\text{-}C_3H_3)$ [M=Rh,Ir]. She attempted on several occasions to grow x-ray-quality crystals of this class of complexes but was unsuccessful because the crystals diffracted poorly. (This problem is probably a function of the fact that the crystals melt at room temperature.) She is currently back at Vanderbilt trying to prepare derivatives of these materials in the hope that they will be more thermally stable and less prone to disorder. She hopes to come back to the Laboratory to pursue some studies on actinides (see Figure 35).

Apara Dave, a graduating senior at Massachusetts Institute of Technology (MIT). Runde was Apara's mentor for the summer. Apara worked on the chemistry of U(VI) in aqueous solutions that contain a number of ligands simultaneously—i.e., carbonate, hydroxide, phosphate, or oxalate. Understanding the chemistry of actinides in these systems helps us to understand their behavior in real waste streams

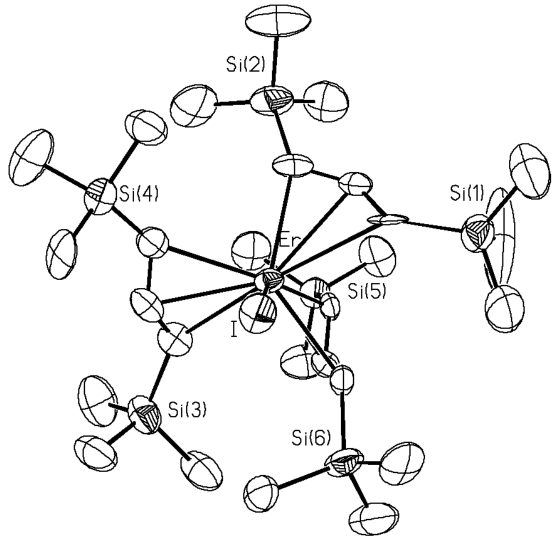


Figure 35. Thermal ellipsoid diagram for $Er(\pi\text{-}1,3\text{-}(SiMe_3)_2\text{-}C_3H_3)_3$.

and to design more effective separation methods. Apara investigated the complexation and stability of U(VI) in the OH/phosphate and the OH/oxalate systems using the characteristic absorbance of U(VI) in the 380–4,230=nm region. Significant changes in the absorption spectrum occur upon the addition of phosphate caused by precipitation of a solid phase; such changes in the absorption spectrum also indicate a change in solution speciation and potential formation of ternary solution species. Further studies must be performed to unravel the stability and formation constants of those complexes.

Oxalate has been used for the reprocessing and purification of actinides, and a few single crystal structures of U(VI) oxalates are known. However, some data appear questionable. For example, the uranyl-oxygen distance in the linear $O{=}U{=}O^{2+}$ moiety in the 1:1 complex UO_cCO_3•$3H_cO$, is reported to be 1.63 Å, which seems extraordinarily short. The U=O distance of most uranyl compounds is above 1.7 Å. Apara crystallized a mixed U(VI) hydroxo-oxalate phase, $K(UO_2)_2(C_2O_4)_2OH$•$4H_2O$, where two bidentately coordinated oxalate oxygens and one bridging OH-group make up the pentagonal equatorial coordination plane around the U center. Preliminary analysis of the x-ray diffraction data revealed two crystallographic uranium atoms within an asymmetric uranyl moiety with bond distances of 1.6 and 1.8 Å Apara also started to try to synthesize a Pu(VI) oxalate, but because of the instability of Pu(VI) in the presence of oxalate, he produced mainly Pu(IV) oxalate (see Figures 36 and 37).

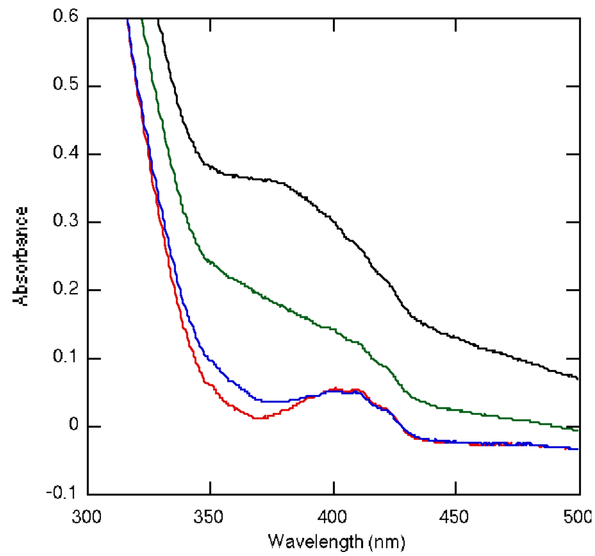


Figure 36. UV-vis absorbance of U(VI) in 3 M TMAOH (red) and after addition of phosphate.

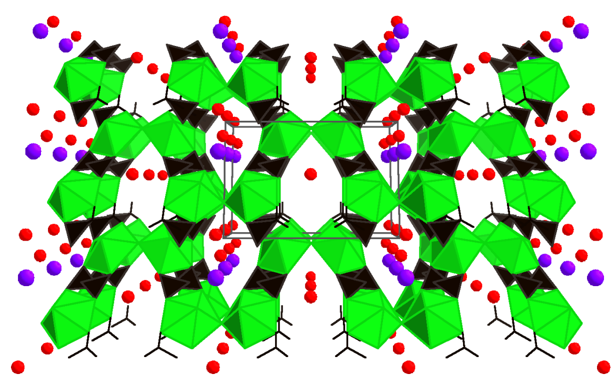


Figure 37. A view of the packing in the two-dimensional network of $K(UO_2)_2(C_2O_4)_2OH$•$4H_2O$.

Karen Cheng, a graduating senior at MIT who will attend the University of California at Berkeley (UC-Berkeley) next year for Ph.D. studies in chemistry. John Gordon of C-SIC was Karen's mentor in the summer of FY02. Karen undertook work aimed at the synthesis and characterization of lanthanide complexes containing one bulky cyclopentadienyl (Cp) ligand in their coordination spheres.

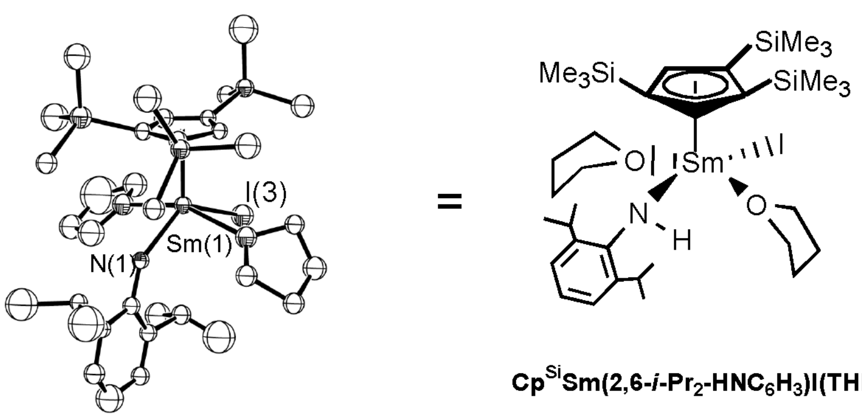
A pervasive problem in this general area of chemistry is the issue of ligand redistribution to produce mixtures of molecules containing different numbers of Cp ligands. The ultimate goal of preparing these molecules is to isolate a series of complexes containing metal main-group element multiple bonds, because these are rare species that are expected to have a variety of reactivities towards small molecule substrates. Many of the fragments that we are targeting as part of the multiple-bonded fragments are dianionic in nature, and an extremely bulky monoanionic coligand is therefore required to stabilize the coordination sphere of the complex and prevent the redistribution issue. Karen managed to isolate a number of new trivalent lanthanide complexes containing the very bulky 1,2,4-tris(trimethylsilyl)-cyclopentadienyl ligand. Notably, Karen was able to isolate species in which there is only one coordinated Cp ligand.

Furthermore, the structural parameters afforded by x-ray crystallography on these species indicate the (trimethyl)silyl groups attached to the Cp ring are approximately 14° above the plane of the 5-membered ring, providing a nice "pocket" in which both the lanthanide ion and the multiply-bonded fragment (when isolated) should reside. We hope this finding will eliminate the redistribution problem in further chemistry as well as allowing us to isolate terminally bound examples of alkylidene, imido and oxo-ligands, which are our ultimate targets.

A picture of a samarium anilido complex that Cheng isolated is shown in Figure 38. Gordon presented some of Cheng's work in an invited talk at the 2002 Gordon Research Conference on Inorganic Chemistry in Newport, Rhode Island.

Anne Gorden, a returning graduate student from UT-Austin. Anne, the student who has been in the program for the longest time, finished her third year under the guidance of D. Webster Keogh (in the C-Division Director's Office) in FY02. She successfully defended her Ph.D. thesis in the spring of FY02 and has moved on to UC-Berkeley as a postdoctoral research assistant. Anne's work on the complexation of actinide ions by expanded porphyrin ligands (Figure 39) is continuing under a new student, Patricia Melfi. Before leaving the program, Anne was able to publish another paper, and her work in this program contributed to two chapters of her thesis.

Richard (Rick) Kelley, a graduating senior at Cornell University who is currently attending Northwestern University, seeking a Ph.D. in chemistry. Rick's mentors for the summer were Gordon (C-SIC) and Marianne Wilkerson of the Advanced Chemical Diagnostics and Instrumentation Group in C Division (C-ADI). Rick worked on the synthesis and characterization of lanthanide alkoxide and phenoxide complexes and, using x-ray crystallography, was able to characterize structurally a number of new systems. A number of these molecules are of interest



$Cp^{Si}Sm(2,6\text{-}i\text{-}Pr_2\text{-}HNC_6H_3)I(THF)_2$

Figure 38. A samarium anilido complex.

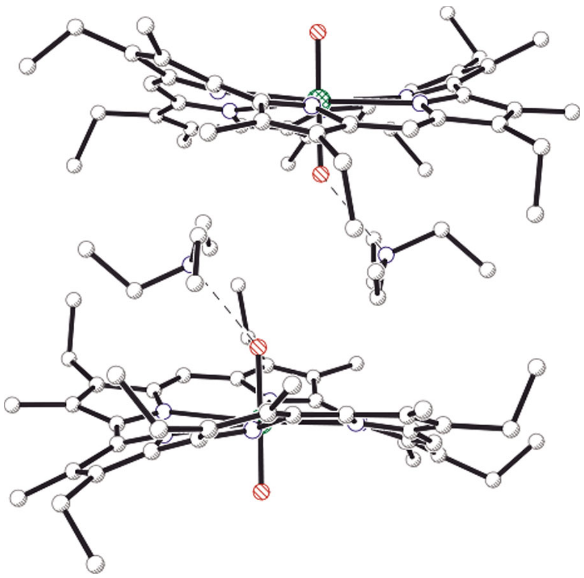


Figure 39. A ball and stick representation of [NpO_2(isoamethyrin)].

because of their novel structural chemistry and, in several cases, because of the apparently complex equilibria between different species in solution. Because of the inherent paramagnetism of many of the complexes that Rick prepared, some of the normal methods of physical characterization (for example, NMR spectroscopy) that we would normally employ are essentially useless in the determination of solution structural characteristics. The solution complexes that were prepared will therefore be investigated using their luminescence characteristics to determine whether or not the molecules characterized in the solid state exhibit more complex solution behavior (such as dimer-tetramer interconversion).

Patricia Melfi, a graduate student from UT-Austin. Patricia's mentors for the summer of FY02 were Keogh and Drew Tait of C Division. As a continuation of the collaboration between the Laboratory and Professor Jonathan Sessler's group, Patricia performed actinide cation complexation studies with designer macrocyclic ligands called expanded porphyrins. These ligands are intensely colored with molar extinction coefficients in the hundreds of thousands. Dramatic changes in the color occur when a metal is complexed. As a result, colorimetric indicator systems could eventually be developed around this technology to detect actinide contamination down to 0.1 µM. Patricia extended these studies to porphyrins, e.g., grandephyrin, with a higher selectivity for the high valent actinide ions, $AnO_2^{+/2+}$ (see Figure 40).

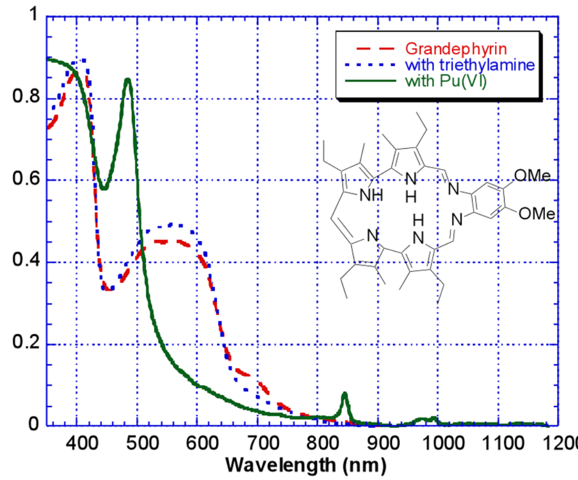


Figure 40. UV-vis spectra of the grandphyrin, before and after binding by Pu(VI).

Piyush Shukla, a returning graduate student from UT-Austin. Gordon again mentored Piyush in the summer of FY02. The collaboration between Gordon and Professor Alan Cowley, Shukla's graduate advisor, has continued to flourish. A manuscript has been accepted for publication in Chemical Communications (one of the premier chemistry peer-reviewed journals). Several more manuscripts are expected to result from this effort. Piyush further enlarged his knowledge of main-group chemistry, developing concepts and more new ligand systems, which will be applicable to lanthanide and actinide chemistry.

Piyush prepared, isolated, and characterized several new ligand systems capable of conferring high electrophilicity on metal centers as well as several new metal complexes derived from them. These findings may have potential utility in olefin polymerization chemistries. The work that Piyush has undertaken has laid the groundwork for a joint proposal in the area that will target the Office of Basic Energy Sciences funding (from the DOE Office of Science). A thermal ellipsoid of a perfluorinated diimine ligand that Piyush prepared is shown in Figure 41.

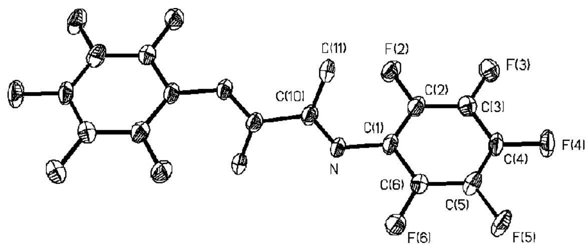


Figure 41. A thermal ellipsoid of a perfluorinated diimine ligand.

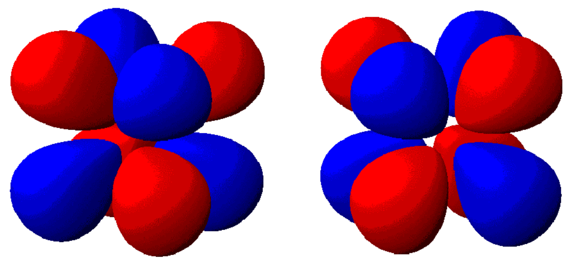


Figure 42. The angular wave function of f-orbitals possibly involved in the covalent bonding of actinide complexes.

Jason Sonnenberg, a graduate student at Ohio State University. Jason's mentor for the summer was Jeff Hay (a Laboratory fellow in the Theoretical Division). The major focus of Jason's research project during the summer of FY02 involved using density functional theory to explore the possible existence and likely structures of various uranyl complexes. He examined the cases of $[UO_2(CN)_4]^{2-}$, $[UO_2(CN)_5]^{3-}$, $[UO_2(CO)_4]^{2+}$, and $[UO_2(CO)_5]^{2+}$ and revisited the case of the complexes $[UO_2(OH)_4]^{2-}$ and $[UO_2(OH)_5]^{3-}$. The calculations used a different relativistic effective core potential that included more valence electrons than previous studies. $[UO_2(CN)_4]^{2-}$ and $[UO_2(CO)_4]^{2+}$ were found to have stable structures with D_{4h} symmetry, although the carbonyl complex had some very low symmetry vibrational modes. The calculated Raman frequency for the cyano complex (876 cm^{-1}) differed significantly from the observed frequency (807 cm^{-1}) in a structurally uncharacterized uranyl cyano complex. Solvent effects were explored to some extent with a dielectric cavity model, but the effects of solvation on structures and frequencies are inconclusive to date. In the pentacoordinate complexes, we found it more difficult to obtain optimized structures, which may indicate a lack of stability with respect to ligand dissociation.

Jason's talk during Symposium 2002 received the prize for "best oral presentation in chemistry." We plan to publish a theoretical/experimental paper when additional experimental results are available on the cyano complexes. Shown below are pictorial representations of the angular wave function of *f*-orbitals possibly involved in the covalent bonding of actinide complexes (Figure 42).

Russell Watson, a graduating senior from Clemson University. Russell is attending UC-Berkeley this fall, seeking a Ph.D. in chemistry. Russell's mentor for the summer of FY02 was Eric Brosha of the Electronic and Electrochemical Materials and Devices Group (MST-11). Russell worked with the High-Temperature Electrochemical Reactors and Sensors Team. Much of this work is dedicated to the development of fuel cells and fuel components for energy security and other military applications.

Short Course, Workshop, and Seminar Series. Future programs will be run as frequently as possible with a target of at least one per month. The current topics under consideration for these presentations are: High Explosives Chemistry, Dirty Bombs, Plutonium Metallurgy, Spectroscopic Techniques in Actinide Chemistry, and Separations Science.

This report would not be complete without mentioning that students and mentors are the true future of this program as well as the next generation of weapons scientists. Figure 43, taken in August 2002, shows the students and mentors from the Nuclear Science Education Program.

The Future. Our intention is to expand the scope of this program to the point at which students will be able to take fully accredited courses not only in *f*-element chemistry and nuclear and radiochemistry, but also in closely allied subjects such as plutonium metallurgy, environmental actinide chemistry, physical methods, and interfacial actinide science.

Institutions represented by students participating in the Nuclear Science Education for the 21st Century in FY02 were UNM, UC-San Diego, San Jose State University, UT-Austin, Cornell University, Ohio State University, Clemson University, Texas Tech, Auburn University, South Dakota School of Mines, Vanderbilt University, MIT, and Colorado State University.

Figure 43. Students and mentors from the Nuclear Science Education Program.

Robotics Competition

"As students use these electronic building blocks to assemble robots, they begin to see how these elements integrate. It is only a matter of time before they begin to improve their design. This ingenuity and creativity naturally lead to advanced problem solving and technological innovation."

Joe Vigil, Los Alamos National Laboratory Robotics Program coordinator

Program Description. The Robotics Competition at Los Alamos National Laboratory (LANL, the Laboratory) is designed specifically to involve the young people of northern New Mexico and surrounding states in a technology that they can understand—one that will excite them and turn them on to mathematics and science.

The need for the Robotics Competition stems from recent data showing that when science scores of high school students across the U.S. were compared to those of high school students around the globe, the U.S. students ranked 20th. Fewer than 3% of the U.S. students who graduate from high school pursue a science-related degree. The U.S. weapons laboratories need a strong pool of U.S. citizens majoring in mathematics and science in order to develop a future workforce. The Robotics Competition provides hands-on, minds-on experiences, creates excitement, and stimulates interest in science and technology by exposing students to the basics of robotics technology with the ultimate goal of recruiting these students into on-site student internships that will lead to future careers at the Laboratory. Figure 44 shows a student receiving guidance from Joe Vigil, program coordinator.

Robotics is the premier integrator in education today because when students design and build robots, they study mathematics, science, technology, and communications. Building a robot is a great educational exercise for a student because it provides applied experience in physics, mechanics, hardware, software, and logic. Robotics

Figure 44. Joe Vigil, Program Coordinator, with Robotics student Eric Kulz from Santa Fe.

students also have to learn how to overcome failure and how to plan and organize a long-term, multifaceted project—necessary skills for many positions in the Laboratory weapons divisions. Robotics is a steppingstone leading students toward becoming the next generation of scientists and technologists because it immerses them in activities using today's technologies.

The 2002 Robotics Competition was structured as a four-day, graded-level series of workshops and competitions with the more advanced students (grades 6 through 12) attending two separate two-day sessions, and the beginning students (ages 6 through 12) attending a basic one-day workshop. By having two separate sessions of the basic workshop, we were able to accommodate the increased abilities of students who showed an extended multiyear interest in robotics technology. The third and fourth days allowed these advanced students to create their own designs (no kits) under the supervision of the robotics instructors.

While it is called a "competition," the emphasis at the Laboratory's Robotics Competition is really on innovation and creativity.

The four-day Robotics Competition culminates each year in local competitions in which each student compares his/her work to the work of classmates. This friendly competition provides the incentive to create designs that make robots more efficient and capable—a major tenet in robotics philosophy.

The recruitment strategy for the Robotics Competition includes site visits and robotics demonstrations at various schools in northern New Mexico; news releases through the Laboratory Public Affairs Office and local newspapers; word of mouth; and the robotics website, http://education.lanl.gov/newepo/k12/robotics/main.html.

The program is successful because the Laboratory has a commitment to using robotics to excite young people about science and technology; because the program has the support of Laboratory upper management; and because a Robotics Competition has developed notable popular appeal.

Performance Goal, Objectives, and Milestones. The goals of the Robotics Competition are as follows: to identify students in middle school through the undergraduate years of college who have recognized talent in the areas of science, mathematics, and technology; to recruit them into the robotics and LANL pipelines; and to expose them to science and technology and thus help create a more diverse hiring pool for the Laboratory.

All milestones were met in fiscal year 2002 (FY02) (Table 11).

Highlights of This Year's Accomplishments. The FY02 Robotics Workshop, held May 2 through May 5, drew more than 140 students from all over the U.S. The advanced workshop was a three-day event (Thursday, Friday, and Saturday) for students from grades 6 through 12. Sunday afternoon was the time for the workshop for younger roboticists (6 to 12 years old) and their parents. The workshop was held in Los Alamos, New Mexico, at the Betty Ehart Senior Center. The center provided space for the workshop and an outdoor patio on which to hold the competitions and events. Because of the location, more senior citizens and Laboratory staff members were able to participate in the workshop than had participated in earlier workshops held in Santa Fe.

The advanced workshop provided a series of graded-level kits to 60 students as they progressed through BEAM (biology, electronics, aesthetics, and mechanics) technology—the educational branch of the new biomorphic robotics science field, named for biology, electronics, aesthetics, and mechanics. Students started with simple solar-engine cars and butterflies and ended up working on four-motor walkers with heads that detected light sources and guided the walker to follow them. Two participants are shown in Figure 45.

Table 11. Milestones for 2002

Date	Activity
November 2001	Confirm sites and dates for workshops
December 2001	Choose site for spring 2003 competition, begin advertising and recruiting
February–April 2002	Recruit technical staff members to attend and help with competition, order supplies for competition and workshops
May 2002	Conduct the four-day workshop and competition
June–September 2002	Conduct workshops

Figure 45. Two students working on their robot at the annual BEAM Robotics competition.

Eight mentors were available to work with students on demand, providing an intense and satisfying hands-on experience for the participants.

The half-day beginning workshop drew 80 students, each accompanied by at least one parent or guardian. These participants built the simplest kits—the solar-engine cars and butterflies. At the end of the afternoon, an informal competition was held for both the "solar rollers" and the aesthetic "solar flapper" butterflies. The highlight of the competition was the sumo-wrestler/solar-walker event.

Robotics played an important role in another program later in the year. The University of New Mexico at Los Alamos (UNM-LA) provided robotics kits for more than 400 students to build during the annual Children's Science Camp held July 29 through August 9 at UNM-LA. The participants were mentored by older students who had taken part in past robotics workshops and events. This approach allowed the older students to gain experience as mentors and to play leadership roles. Patricia Chavez, director of UNM-LA's Children's College, said, "The students really enjoyed the hands-on experience of building, testing, and racing the robots." She added that the robotics workshop is among students' favorite classes at the Children's Science Camp each year. "Next year we plan to hold at least one week of robotics during the Children's College," she said.

Another FY02 highlight was the encouragement provided by LANL senior managers for the idea of working with the Navajo Nation and Jemez Pueblo to support robotics workshops in the field and in rural, high-minority school districts. Workshops sponsored by the Northern New Mexico Systemic Initiative were held in the Shiprock area May 23 and 24. Laboratory scientists and students from past robotics events worked with more than 100 Native American students. One headline in the San Juan Sun in the Four Corners area said, "Navajo Nation, Los Alamos scientists work together for youth."

Several groups at the Laboratory took a special interest in the Robotics Competition. Kurt Moore of the Space and Atmospheric Sciences Group at the Laboratory (NIS-1) joined the Robotics Competition in FY02 as a mentor for the workshop participants. NIS-1 provided robotics demonstrations during the workshop to showcase how the Laboratory uses robotics to solve real-world problems such as how to make satellites track the sun while in space. The Space Instrumentation and System Engineering Group (NIS-4) sponsored Ian Bernstein, a past participant in the Robotics Workshop, allowing him to work on robotics projects in the group during the summer. Bernstein is a robotics student at New Mexico Institute of Mining and Technology in Socorro, New Mexico. He plans to return to work for NIS in the summer of 2003 and will continue to serve as a student mentor for the spring Robotics Workshop in May 2003.

Finally, students at the Laboratory's *Go Figure!* Summer Institute in June 2002 also were able to build robots during their two weeks at the Laboratory.

Comments from Robotics Workshop Participants. One way to evaluate a program's success is to assess what students say after it has ended. Following are several comments from those who participated in the Robotics Workshop.

"I liked working side-by-side with the senior citizens of this community. Many of them are retired from the Lab and really know a lot about electronics and math."

"Joe Vigil and the group from Canada make this event challenging and don't always give us answers to our questions directly but lead us to use our own ingenuity to figure out complicated electronic problems."

"Nowhere in the world is there a better robotics event!"

"I don't speak English very well, but I was able to understand how to build a robot while working on my English and math skills."

"There were a lot of scientists from the Lab who came out to help us out!"

"I enjoy building robotics and then testing them to see if they work!"

"The competition is always a lot of fun, and I like the fact that cheating and making your two-motor walker better is encouraged at the competitions."

"My bilingual class in Santa Fe uses the activities on the robotics website. They are challenging, and we interact with scientists like Kurt Moore from LANL."

"I like working with the students who help us build since they are students just like us."

"I am an undergraduate student from the University of California, and I would make the drive again next year. This is a fantastic program!"

Summer School in the Physical Sciences for Undergraduates

Program Description. Many of the best students going into scientific research are not, as in the past, selecting the physical sciences. Instead, they are choosing biology and computer science. This problem has caused concern for international physical societies as well as Los Alamos National Laboratory (LANL, the Laboratory) because the physical sciences form the core research areas of the nation's nuclear weapons stewardship. They are especially important to nuclear weapons design and safety. To meet the continuing need for top scientists, the Laboratory needs stimulating programs to attract and retain the highest-quality students. Doctoral-level professionals are needed most. Early contact with them remains essential, and we must implement long-term, integrated efforts targeted at each stage of a student's progress through the formal educational process. National studies indicate that the best time to influence the choice of career comes during the last few years of undergraduate school because during that time period, students have gained the technical skills and background to appreciate scientific problems but have not yet specialized in particular areas or fields.

The Summer School in the Physical Sciences (SSPS) was designed to be the first stage in a critical-skills development program, identifying, attracting, and training top-flight students from around the country in the physical sciences that are of such importance to nuclear weapons.

SSPS, a joint program of the University of New Mexico (UNM) and the Laboratory, completed its 13th year in fiscal year 2002 (FY02). The program's recruitment activities are national in scope. They target upper-level undergraduate students who will soon be making career choices, and they focus on a diverse pool of applicants.

Program participants are given intense and broad exposure to basic research in many fascinating, diverse areas of physics through lectures by distinguished scientists and through mentored term projects. The lectures and projects include such disciplines as astrophysics, weapons, condensed-matter physics, plasma physics, biophysics, laser physics, atomic physics, molecular physics, and optical physics.

Additionally, SSPS has several broader goals: teaching certain basic physics skills not commonly emphasized in the university curriculum; introducing high-performance supercomputing; and fostering a personal interaction between research scientists and students. We believe that knowledge of the workings of scientific research, of frontier discoveries, and of the newest computer techniques will greatly aid students, no matter what their ultimate career choice.

For the past ten years, SSPS has been funded by a National Science Foundation Research Experience for Undergraduates site grant to UNM, by the Critical-Skills Development Program at the Laboratory through a Department of Energy (DOE)/Defense Programs (DP) grant, by in-kind support from the Laboratory's Theoretical Division, by the UNM Center for Graduate Studies, and by the UNM Department of Physics and Astronomy. In FY02, for the second year in a row, we received generous support from line management in the Nuclear Weapons program at the Laboratory through the Advanced Strategic Computing Initiative.

The 2002 SSPS was divided into two complementary activities—lectures and a mentored student research project. The lectures focused on current "hot topics" in the field of physics, drawn from the speakers' own research projects. The lecturers introduced basic physical concepts from the perspective of ongoing research efforts. This mode of presentation gave the students an opportunity to participate in new investigations. To complement the lectures, each student worked on a summer research project under the guidance of a mentor from the senior scientific staff of the Laboratory or UNM. A variety of projects were available, many of them concentrating heavily on high-performance supercomputing. The mentors carefully crafted each research project to fit the background of the student in order to guarantee the greatest and most effective participation. We have found that this dual track of lectures and research best stimulates the students toward an active interest in science and avoids the pitfalls of a program devoted exclusively to one track or the other. The lectures look outward, showing the vast, exciting nature of current global scientific research, while the mentored projects look inward, developing participants' skills in analysis and problem solving.

In FY02, we kept the 10-week term, begun three years ago at the behest of students and mentors who felt that the extra time led to more productive projects. Given the enthusiastic response to this year's projects, we could easily lengthen the term.

The students participating received three hours of course credit from UNM for Physics 501. This credit has always been readily transferred to home institutions and, in many cases, has substituted for a senior research project. We held the lectures in the mornings and reserved the afternoons for research in an attempt to strike a balance between these two activities. Classes and computer sessions were held on the campus of UNM-Los Alamos. The UNM computer center has a fast link to the Laboratory network, provides powerful local capabilities, and is close to student housing. Its use encouraged a natural cohesiveness within the class. Class spirit was further fostered by tours of Laboratory facilities and local points of interest and by scheduled activities outside the classroom. The friendships made during SSPS form an important, enduring feature of the program noted by almost all students, past and present.

Although this basic formula has served SSPS admirably, we continue each year to experiment with new educational projects and approaches. This year we developed a special session on astrophysics that was presented by members of the nuclear weapons design groups.

Reflecting the nature of its sponsorship, SSPS uses codirectors, each one taking responsibility for particular tasks in operation and organization that are assigned, based on resources, personnel, and location. For example, UNM has excellent facilities and staffing to handle the vital task of recruiting and to provide classroom and computer access, but the Laboratory has a very large on-site physical sciences technical staff from which to draw mentors and lecturers.

Performance Goal, Objectives, and Milestones. We met the main performance objective in 2002, encouraging undergraduate students to pursue research careers in the physical sciences—an objective that is vital to the DOE/DP mission. Meeting this objective has become more critical as computer firms and the biosciences continue to attract the best university students. The short-term milestones of providing exciting projects and lectures to stimulate the students were amply met in 2002. For the intermediate term, we have repeatedly influenced students to continue research activities, to work on advanced degrees with joint Laboratory and university mentors, and to begin tenure-track university positions with continued strong ties to Laboratory personnel. Because undergraduates may take seven or eight years to complete a doctorate, we are just beginning to glimpse the long-term effects of this program.

DOE/DP Mission Benefit. SSPS began as an internally funded project within the Laboratory weapons program. It was intended to encourage greater participation by outstanding students in research areas deemed vital to many DP missions. Because funding and policy changes occurred in 2001, we have, in some respects, returned more strongly to this initial purpose. The basic goals of SSPS closely align with the recommendations of the Chiles Report, especially item #7, to "replenish the essential workforce needs" of the weapons laboratories. Specifically, the program creates a high profile for the effort to encourage people to study the physical sciences by maintaining a national recruitment process that targets such students and teachers at more than 2000 universities and colleges and by using distinguished lecturers from academic institutions. The school serves as a 10-week intern program in which students become actively involved in a variety of research programs at the Laboratory. In addition, SSPS classes have had strong participation by women, consistently at a percentage well above that of university physics programs at the same level. We have also employed many women scientists as mentors and lecturers to serve as role models.

Programs like SSPS that concentrate on undergraduate students provide a unique and powerful vehicle for recruiting highly talented students with tremendous career potential into areas of critical interest to the national security establishment and to DOE in particular. As indicated by our evaluations, SSPS fosters in students an extremely positive view of the Laboratory and its multifaceted research programs. We must build on this enthusiasm with a coordinated series of interlocking programs that follow and attract students all along the lengthy path to a professional degree.

Highlights of This Year's Accomplishments.

Mentored Research Project:

In FY02, 19 students from universities in 14 states participated in the combined SSPS curriculum of lectures and individual research projects. We had broad participation from mentors representing UNM, six different Laboratory divisions, and 17 Laboratory groups. Nineteen projects, supervised by 26 mentors, covered such diverse areas as quantum computing, plasma shocks and confinement, warm-dense matter, viral infections, materials simulations, and femto-second spectroscopy. The names of principal mentors and students appear in Table 12.

All students submitted detailed final reports—crafted along the lines of a standard scientific

Table 12. SSPS Mentors and Students 2002

W. Hlavacek (T-10)	Anderson, Hank
G. Kalosakras (T-CNLS) & K. Rasmusen (T-11)	Anjum, Sajid
R. Onofrio (C-INC/AFF) & L. Viola (CCS-3)	Chadderdon, Eleanore L.
G. Kenyon (P-21)	Collman, Forrest
S. .Cohen (LANSCE-6)	Dedini, Erik L.
M. Tacetti (P-24)	Harris, Margaret L.
J. Grondalski (T-4) & D. James (T-4)	Hume, David B.
J. Faeder (T-10)	Kozdon, Jeremy E.
D. Streck (T-8)	Leary, Cody C.
M. Stan (MST-8)	Logan, Marsha J.
S. Mazavet (T-4) & L. Collins (T-4)	Magee, Richard M.
C. Olson Reichardt (T-12)	Mahoney, Katherine E.
G. Rodriguez (MST-10) & S. Clarke (MST-10)	Pangilinan, Monica O.
C. Jarzynski (T-13)	Sonderegger, Morgan A.
J. Boissevain (P-25)	Strycker, Glenn L.
M. Murillo (T-15) & D. Gericke (T-15)	Tharp, Tim D.
S. Srivilliputhur (MST-8)	Waldron, Amy C.
P. Milne (T-6)	Watje, Philip K.
M. Hyman (T-7)	Wickland, Timothy A.

paper—on their research accomplishments. The papers will be bound into a Laboratory publication (LAUR-02-5599) for general distribution. To aid students in writing these reports, we held a special class on technical writing featuring Lee Collins, an editor to *The Physical Review*. SSPS emphasizes the research experience, giving the students a first-hand taste of a technical project. The program is generally too short for the production of a finished, polished, and publishable piece of scientific research, but several students plan to continue work on their projects, using them either as independent endeavors or as a part of a senior research course at their respective institutions. We anticipate that these continuing efforts will produce publications in refereed research journals. Students in the FY01 SSPS reported their research in articles that appeared in *Physics Letters* and used their findings as contributions to meetings such as the International Conference on Systems Biology and the annual meeting of the Institute of Nuclear Materials Management. One of our students attended a Gordon Conference with her mentor as part of her project.

This year, many of the students participated in Symposium 2002, a scientific meeting organized by the Laboratory that included student talks and posters as well as booths from universities and corporations. Our students gave one technical talk and 10 poster presentations.

Five of our past students returned to the Laboratory this summer to work with various research groups. Their return was arranged through contacts and projects initiated through SSPS. Among those who returned were one member of the SSPS class of 1999; two members of the class of 2000; and two members of the class of 2001. In addition, a recent PhD recipient from the University of Nevada at Reno (SSPS class of 1994) has accepted a postdoctoral position in the Atomic and Optical Theory Group at the Laboratory.

Lectures:

In addition to participating in a mentored research project, FY02 students attended a full set of lectures on an extensive range of topics as outlined in greater detail in Table 13. These lectures serve as a perfect vehicle to highlight high-quality research programs, and they provide marvelous recruiting opportunities. Distinguished lecturers were drawn from outside universities and research organizations, from UNM, and from the Laboratory (seven divisions and 16 groups). All lecture slots filled rapidly as soon as the program announced that they were available. This fact attests to the popularity of SSPS. The outside participation was our largest yet. Among those who spoke were Professor S. Carney (Illinois); Professor R. Wyatt (Texas); and Dr. S. Schneider (Toronto). Carney was a very special speaker because he is an alumnus from the SSPS class of 1995. UNM was a strong participant again, a fact that highlights the important ties generated by SSPS between the university and the Laboratory. The junior scientific staff members at the Laboratory—primarily postdoctoral fellows—were enthusiastic participants. The opportunity to speak at SSPS often provides their only experience in preparing and giving lectures to a student group.

This year, SSPS included a pilot program in close association with the nuclear weapons design groups within the Laboratory. This program involved lectures by members of these groups on topics in astrophysics that closely relate to problems in weapons physics. This exercise provided substantive contacts between talented students and members of the weapons community.

The lecture series is open to all other Laboratory educational projects, and we routinely distribute the schedule to the Laboratory undergraduate (UGS) and graduate (GRA) programs. Students from other Laboratory programs attended many of the lectures.

Activities:

In addition to the formal lecture and mentor programs, we arranged a wide variety of related activities for the students. They toured various Laboratory facilities, including the Los Alamos Neutron Science Center. Our traditional "Night at the Santa Fe Opera" (SFO) continued. Students attended the opera "L'Italiana in Algeris." We have, over the years, fostered a special relationship

Table 13. Lecturers and Titles

Peter Adcock	MST-11	Fuel Cells and Electrowinning
Stephen Becker	X-2	Approximating the r-Process on Earth with Thermonuclear Explosives: Lessons Learned and Unanswered Questions
Eli Ben-Naim	T-13	Statistical Physics of Granular Matter
Howard Bryant	UNM	Tweedledee and Tweedledum Near the Speed of Light
Scott Carney	Illinois	Near Field Optics
Frank Cherne	MST-8	Atomistic Simulations of Liquid
Lee Collins	T-4	Introduction to the Opera, Technical Writing
Christian Forst	B-1	Bioinformatics/Computational Biology, Network Genomics, and Systems Biology
Andrew Hime	P-23	The Sun Shines Underground
Michael Holzscheiter	P-23	Ion Traps as a Tool for Precision Measurements
Roger Johnston	C-ADI	Tamper Detection, Nuclear Safeguards, and Treaty Monitoring
Garrett Kenyon	P-21	Simulating Biological Neural Systems
Web Keogh	C-DO	Overview of the Chemistry of the Light Actinides
Roberto Onofrio	C-INC	Cold Atom Physics
Martin Piltch	MST-6	Quantum Electronics
Cynthia Reichardt	T-12	Simulated Sand: Tumbling, Rolling, and Shaking
Sara Schneider	Toronto	Quantum Optics
Sally Seidel	UNM	Topics in Particle Physics
Marius Stan	MST-8	Thermodynamics of Everything
Daniel Steck	T-8	Classical and Quantum Chaos
Tim Thomas	UNM	Relativistic Heavy Ion Reactions in Astrophysics
Eddy Timmermans	T-4	Cold Atom Physics
Lorenza Viola	CCS-3	Quantum Information
Robert Wyatt	UT Austin	Quantum Fluid Dynamics
Yi Jiang	T-7	Soft Matter

with SFO and have been able to acquire block tickets so that the whole class can conveniently attend a single performance. This event fits in well, given our recruitment from liberal arts colleges and the recent trend toward double majors in the sciences and the arts (see Figure 46).

Recruitment and Demographics. We recruited nationwide, emphasizing students from schools with few or no graduate research programs. UNM handled the recruitment phase, sending mailings to all members of several American Physical Society Divisions (approximately 2,000 fliers). In addition, a color poster was sent to most physics, chemistry, and astronomy departments in the United States. Special mailings went to minority-designated institutions. We have developed a website (http://www.phys.unm.edu/LASS) that provides general information about SSPS and allows for direct applications. This site will undergo a major revision in FY03, when we hope to add more personal touches. In 2002, we received more than 120 applications, up slightly from 2001, and admitted 19 students.

The 2002 class was very strong scholastically, filled with many honors students. The students came from 16 different universities from Massachusetts to California. The schools represented ranged from liberal arts colleges with small research programs to large research-oriented universities. A complete list appears in Table 14. Participation by women increased to 32%. One participant was a Native American; one was African American; and three were Asian.

Figure 46. Student Activities 2002.

Table 14. SSPS Class 2002

University of New Mexico	Anderson, Hank
University of California (Berkeley)	Anjum, Sajid
Harvard University	Chadderdon, Eleanore L.
Princeton University	Collman, Forrest
Humboldt State University	Dedini, Erik L .
Duke University	Harris, Margaret L .
Kentucky University	Hume, David B.
University of California (Santa Cruz)	Kozdon, Jeremy E.
University of Puget Sound	Leary, Cody C.
Benedict College	Logan, Marsha J.
Bucknell University	Magee, Richard M.
University of Notre Dame	Mahoney, Katherine E.
Cornell University	Pangilinan, Monica O.
Massachusetts Institute of Technology	Sonderegger, Morgan A .
University of Notre Dame	Strycker, Glenn L .
DePauw University	Tharp, Tim D.
Bluffton College	Waldron, Amy C.
University of New Mexico	Watje, Philip K.
Harvard University	Wickland, Timothy A.

Evaluation. Evaluation of the program has always been difficult. We performed an impact evaluation, asking the students the immediate importance of their participation. The response this year was remarkably similar to that of previous years. The following general findings about the course emerged: (1) it is well organized and at about the right level, (2) it helped improve students' understanding of basic concepts in the field, (3) it required a reasonable amount of work, (4) it provided skills applicable to students' careers, (5) it provided an appreciation of high-level computer power, and (6) it fostered an informality that nurtured interactions with renowned scientists. We were gratified by the response from most of the students that SSPS had "renewed their interest in science and computation." The short-run effects of the program were clearly very positive.