fermilab report

September/December 1990

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On the cover: Part of the low-beta insertion at BØ. *Photograph by Reider Hahn, FermilabVisual Media Services.*

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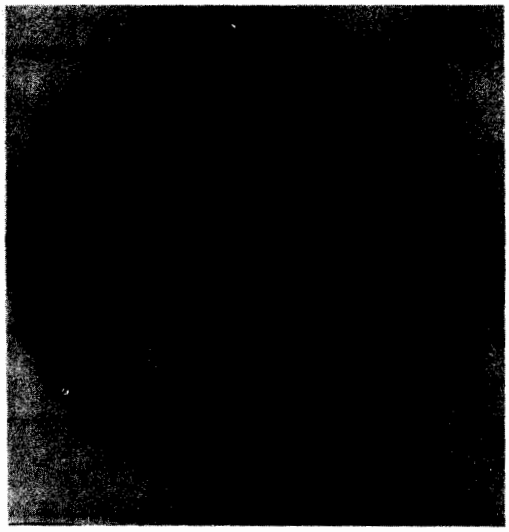
Magnet Project Boosts Superconductivity Expertise

By *Kate Metropolis*



Cross section of a superconducting strand used in Fermilab's low-beta magnets.

Striking advances in superconducting materials, wire manufacturing processes and cabling techniques have been realized in the development of a new series of focusing magnets for the Tevatron. The superconductor in the magnets has achieved the highest critical current density that has ever been seen in a working accelerator magnet: 3,100 amperes per square millimeter at 5 teslas, nearly twice that of the superconductor in the original Tevatron magnets. This accomplishment is the result of the combined efforts of three national laboratories, a university research group and American industry.

Fermilab's pioneering work in applied superconductivity began more than a decade ago, when the Laboratory began to design the Tevatron, the highest energy accelerator in the world today. The Tevatron's four-mile-long ring of superconducting magnets keeps two beams of particles circulating past accelerating stations that increase the particles' energy until they are traveling almost as fast as light. Much of what is known about the ultimate structure of matter has been revealed through the study of what happens when high-energy particles collide head-on—and there have been more immediately practical benefits from the research as well.

"Every program in superconductivity that there is today owes itself in some measure to the fact that Fermilab built the Tevatron and it worked," says Bob Marsh, of Teledyne Wah Chang, the world's largest supplier of superconducting alloys and a participant in the development of the new magnets. He cites high-energy physics as a driving force in the development of practical applications of superconductivity. Without the success of the Tevatron, he believes, "there would probably be no magnetic resonance imaging today. Fermilab provided the impetus necessary for industry to make better superconducting wire at a lower cost."

Although physicists have been running experiments with the Tevatron since the early eighties, their quest to learn more about the fundamental laws that shape the physical universe continues to spur the domestication of superconductivity. "We all knew that we could do better than the Tevatron magnets—that we'd just begun to tap their potential," says Fermilab physicist Al McInturff, who coordinated development of the new low-beta quadrupole magnets. Twenty will be installed over the next year to squeeze the particles together into tighter bunches just before the paths of the two beams cross. The factor-of-two increase in current-carrying capability doubles the probability that a proton and an antiproton will collide head-on, increasing the opportunity for physicists to record and study very rare events.

Improving superconducting wire

Funded by the Department of Energy's High Energy Physics Advanced Technology R&D Program, researchers at Fermilab, Brookhaven National Laboratory, Lawrence Berkeley Laboratory and the University of Wisconsin at Madison collaborated with their counterparts in industry to optimize the superconductor for the magnets. Although ultimately commercial contracts for the alloy and the wire were awarded on the basis of bids, several companies who are competitors in the marketplace joined forces in the research and development phase of this project.

Four years ago, a leading authority on superconductors, Professor David Larbalestier of the University of Wisconsin at Madison, took on the challenge

The University of Wisconsin at Madison collaborating group, under the leadership of Professor David Larbalestier, included: (l. to r.) K. I. Faase, P. J. Lee, D. C. Larbalestier, W. L. Starch and Y. E. High.

of improving superconducting wire so it could carry sufficient current for the new magnets. Larbalestier's group, which included a microscopist and both graduate and undergraduate students, succeeded in bettering both the intrinsic and the extrinsic properties of the superconductor. "If a chain is only as strong as its weakest link," Larbalestier explains, "you have to make the material of the link as strong as possible. But you also have to make sure that the links are welded properly—that it's mechanically strong."

To enhance the upper critical field of the magnets, the group decided to incorporate tantalum into the usual alloy of niobium and titanium. "This was the risky part," says Larbalestier. "It's difficult to melt these three metals in a chemically uniform fashion. But McInturff said, 'Let's gamble.' "

Mechanical stability was another issue. The University materials scientists learned that if titanium from the alloy diffuses into the copper that sheathes the superconducting filaments, brittle compounds can form that generally degrade the properties of the wire. To reduce this risk, the industrial partners suggested that the alloy be encased in a layer of niobium to create a diffusion barrier.

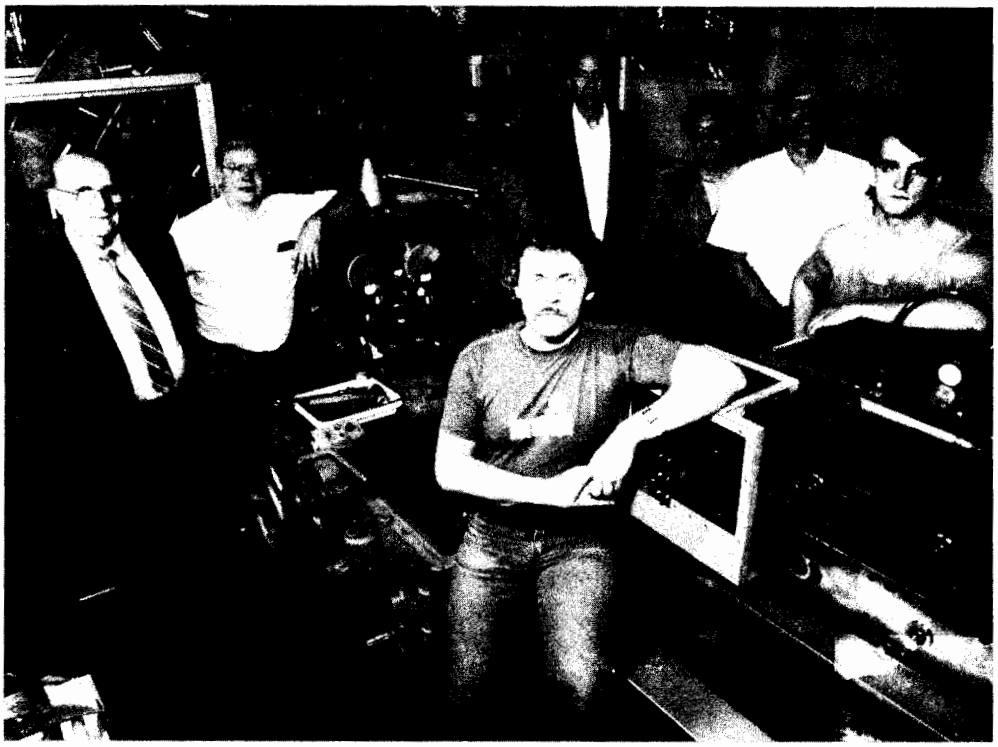
Daring new approach rewarded

Tests and detailed microscopy carried out at the University and the national laboratories confirmed that uniform samples of the superconductor could be made and that the current-carrying capability was very high. But it was by no means clear to the Intermagnetics General Corporation (IGC)—a company in Waterbury, Connecticut, specializing in commercial applications of superconductivity—that the techniques that worked in the laboratory would be economical for industrial production. Their concern was that the hotter, longer heat treatments prescribed by the Wisconsin group for the alloy—manufactured by Teledyne Wah Chang of Albany, Oregon—would render it too brittle for long lengths of the 21-mil-diameter wire to be drawn. One of the high points of Larbalestier's work on the project was the day he got "a very excited" phone call from IGC. The company had just drawn a 120,000-foot length of the wire. "They said they'd never had such a good piece," Larbalestier remembers.

"We had looked at these new techniques before the low-beta quad project came along, but we were unwilling to make the jump," said Dr. Hem Kanithi of IGC. He reports getting excellent results on a production scale. "This is probably the first time that anyone has made such a large quantity of fine superconducting wire. Having processed a batch of about four tons gives us the confidence to apply these techniques to other superconductors, such as those used in magnetic resonance imaging."

State-of-the-art cabling techniques

Fermilab turned to the Applied Superconductivity Group at the Lawrence Berkeley Laboratory (LBL) for help in twisting the wire into cable. Cabling superconducting wire is more demanding than cabling ordinary copper wire: the wire must be highly compacted to ensure a high over-all current density, but



The Applied Superconductivity Group at LBL included (back row, l. to r.) John Royet (LBL), Ron Scanlan (LBL), Hugh Higley (LBL), Clyde Taylor (LBL), Phil Rizzo (LBL), Scott Graham (LBL) and Bob Tuskey (Fermilab) and (front row) Bob Jensen (Fermilab).

the heat treatments that help ensure a uniform alloy also reduce its ductility. LBL's considerable expertise in cabling superconductor grew out of an early magnet design they had come up with for another accelerator. The group had had trouble getting the 30-strand wire their magnet required made commercially, so they decided to develop the technology themselves and then transfer it to industry.

"We wanted something that would allow us to make a precise rotation and then also transfer that motion to a linear drive to take up the cable," Ron Scanlan, a metallurgist in the LBL superconductivity group, explains. "One of our engineers realized that a lathe automatically does those operations, and we

were able to find a very large one in storage out in the Midwest. We had it shipped out and made a wheel to attach the spools to, and worked out the technique for making cable." This experience enabled LBL to write the specifications for a production cabling machine, which was installed at New England Electric Wire Company in the fall of 1988, where "it has worked out quite well," according to Scanlan.

Table I

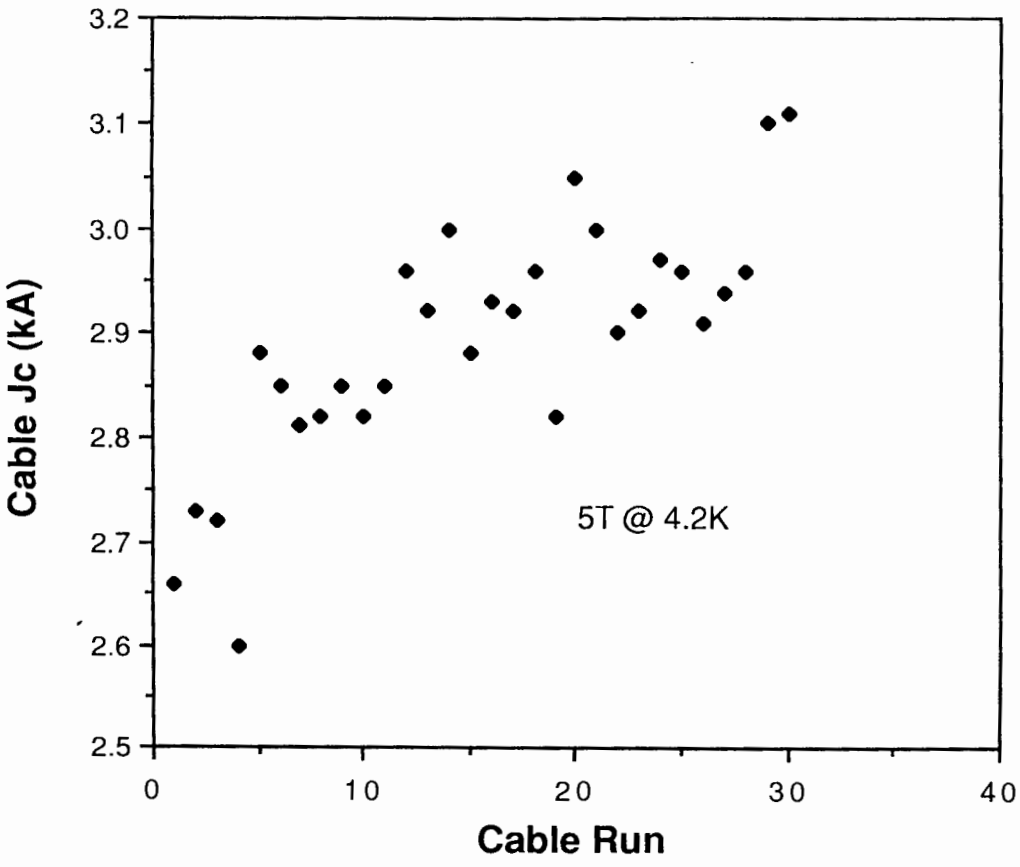


Table I: shows the increase in cable critical current density over the two-year cabling period.

Table II

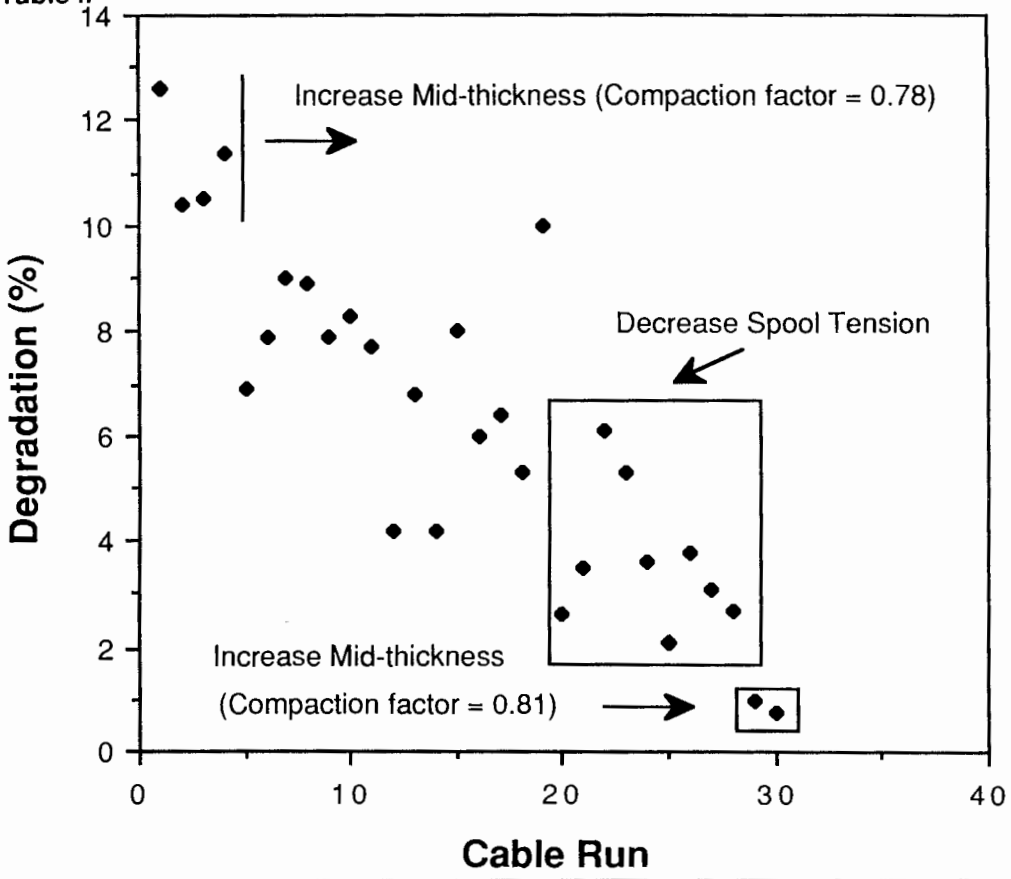


Table II: shows the reduction of degradation as a function of cable run.

To form a cable for the Fermilab low-beta quadrupoles, 36 strands of wire are carefully twisted together over a mandrel, so that each one lies next to, but doesn't cross over, the adjacent strands. It is then flattened in a Turk's-head roller, slightly more on one edge than on the other: in cross section it resembles a keystone. This shape allows the cable to be wound tightly into a magnet, for maximum current density and mechanical stability. However, this process must be performed with great care. If the cable isn't sufficiently flattened, it tends to spring back to its unrolled round cross section. On the other hand, rolling too hard can damage the strands. "Our cable could not have been made a few years ago," says McInturff.

In the meantime, both Fermilab and LBL came up with innovations to ward off the demons that can ruin cable. LBL developed specifications for how far the superconducting wire can be bent without breaking and how much variation in the springiness of the wire there can be to ensure that it can be cabled satisfactorily. A magnetic device controls the tension on each strand more accurately and precisely than the standard mechanical regulator. Sophisticated mathematical modeling by LBL's John Royet has improved the shape of the mandrel and its position relative to the Turk's-head roller to minimize the number of crossed strands. On-line quality sensors developed by John Carson at Fermilab have reduced deviations in the thickness of the cable by almost an order of magnitude, which is extremely important for such densely wound magnets.

Lighting the way for the SSC

The collaboration of superconductor experts and the physicists who will perform experiments with the upgraded Tevatron are not the only ones to benefit from the development of the new magnets. Many of the advances came at a crucial time in the work on magnets for the Superconducting Super Collider (SSC), a fifty-three-mile-long particle accelerator with twenty times the energy of the Tevatron that will be built by the Department of Energy near Dallas, Texas, over the next decade.

Like the SSC magnets—but unlike the original Tevatron magnets, the Fermilab low-beta quadrupoles have a "cold-iron" design, in which the cryostat surrounds the iron collars that restrain the coils under the tremendous Lorentz forces generated when the magnet is operating. The low-beta quadrupoles provided insight into the manufacturability of both the magnet and the cryostat.

The low-beta quadrupole work also blazed the trail for cabling 36-strand wire, which is a feature of the present SSC magnet design. In addition, according to David Larbalestier, the success of the superconductor for the low-beta quadrupoles suggests that no intrinsic limit to the material exists that might jeopardize the SSC magnets. "It's a very important proof of principle," he says.

1990 Summer Precollege Education Programs

by *Marjorie G. Bardeen*

Summer is the busy season for Fermilab precollege education programs. This summer, the Laboratory hosted 95 high school students and 227 elementary and secondary teachers in 9 education programs sponsored by the Education Office, the Equal Opportunity Office and Friends of Fermilab. In addition to the participation of 61 Fermilab employees, over 125 scientists and teachers gave presentations to the participants.

"We believe that the Department of Energy, with its unparalleled collection of scientific laboratories, facilities and experts, has the potential to set a highly visible and creative example of educational collaboration for the federal government and the private sector. We will initiate and support a series of vigorous and immediate steps to help strengthen mathematics and science education in the nation."
— James D. Watkins, Admiral, U.S. Navy (Retired), Secretary of Energy

Fermilab is able to offer so many programs because we utilize expertise from various groups—teachers, science education specialists, scientists—with minimal interference with their regular jobs. We collaborate with a cadre of outstanding dedicated teachers who are involved from the beginning of the program development process. Master teachers are given recognized leadership roles in designing and conducting the summer programs. The major credit for the success of the programs rests with these professionals.

Student programs

Fermilab programs provide high school students an exposure to the environment of a research laboratory, an incentive to continue their studies in mathematics and science and an opportunity to develop work skills. Too many

young people—particularly female and minority students who represent a largely untapped resource—lack the preparation they need to advance to higher education and to careers in scientific and technical fields. Fermilab encourages students to pursue mathematics and science careers through the following summer programs:

DOE High School Honors Research Program in Particle Physics is a research program for gifted high school students. Students are supervised by high school physics teachers and spend two weeks working and studying at Fermilab. The program includes lectures by Fermilab staff physicists, lab tours and tutorial sessions, as well as on-the-job assignments with current Fermilab experiments.

"The DOE Honors Program was one of the best experiences of my life. I learned so much and had fun doing it."

The 1990 program was held June 17 - July 1. Students came from the fifty states, the District of Columbia, Puerto Rico, Canada, the Federal Republic of Germany, Great Britain, Italy, Japan and Mexico. Fourteen of the 59 participants had just completed their junior year in high school; the others were recent high school graduates. In addition to attending *Saturday Morning Physics* lectures, students worked in ten research groups with the following experiments: E687, E791, E740, E771, E761, E690, E706, E704, E672 and E665. Each research group wrote a report and gave an oral presentation describing the nature of the experiment to which they were assigned and the "proton economy" at the site. Field trips included a Chicago tour of the Museum of Science and Industry, the Sears Tower and pizza at Giordanos, and a study of the physics of amusement parks at Great America.

Fermilab-EAL Summer Science Experience, a collaboration between Fermilab and Educational Assistance Ltd. (EAL), provides a science program for selected high school students involved in the EAL College Opportunity Program. The students spend one week at the Laboratory attending classes, visiting laboratory facilities and meeting with personnel to discuss career opportunities. The program is supervised by a high school physics teacher.

In 1990, 12 students, none of whom had studied physics, visited Fermilab from July 22-28. Six came from the Lawndale neighborhood of Chicago, three from Green County in southwestern Pennsylvania and three from Midland, Michigan. In class, the students learned about the world of sub-atomic particles through the Beauty and Charm curriculum. They spent an afternoon in the prairie, visited the Neutron Therapy Facility and SciTech Museum and conducted and analyzed playground physics experiments. Students enjoyed working their minds at Fermilab and said their teacher was "probably the best classroom teacher they had had."

Summer Youth Employment and Training Program is a nine week program. High school interns from DuPage, Kane and Kendall counties are allowed to work a maximum of 35 hours per week. In 1990, two students worked at Fermilab.

Target: Science and Engineering hosts 25 high school students, the majority from Chicago schools, for six weeks. In the mornings, the participants work side-by-side with a scientific, engineering or technical mentor at Fermilab. In the afternoons, the students attend classes and receive assistance in the preparation of an individual or group research project.

The 1990 program was held from June 25 to August 3. The 24 participants came from 17 high schools. Seventeen students were from Chicago. Work assignments ranged from clerical and typing to entry level computer operations training and assisting scintillation counter assembly. Research projects, developed under the supervision of three high school teachers, included lasers and holography, a polarization box and 3-D polarization, a computer math and logic circuit and photosynthesis.

"I learned all about physics and its work environment. I also saw what is expected of me if I were to enter the field of physics. I gained patience and became more efficient."

Teacher programs

By reaching teachers, the Fermilab programs endeavor to influence indirectly a maximum number of students. Too few teachers receive training of the depth and currency required to deliver mathematics and science instruction in a way that sparks student interest. Our programs enhance the teachers' backgrounds in basic science; demonstrate successful and lively teaching techniques; and expose teachers to current developments in scientific research, basic objectives and problems in modern science, and contemporary relations among science, technology and society. Fermilab brings teachers to the Laboratory through the following summer programs: ·

The DOE Teacher Research Associates Program (TRAC) and the TRAC Graduates Program provide research experiences for junior high and high school teachers. The programs include a national and a regional component. Candidates for the national program are nominated by their state education departments. Candidates for the regional program apply directly. Teachers are assigned to a scientist or engineer involved in a research project and make contact with many professional researchers.

In 1990, 23 high school and 3 junior high school teachers held Fermilab research positions; 12 of them were new to the Laboratory, and 9 had never held a similar appointment. In addition to 21 Illinois teachers, participants came from Alaska, Arizona, Colorado, Indiana and Nebraska. Teaching assignments of the participants included: physics,12; mathematics, 6; computer science, 5; physical science, 3 and chemistry, 2. Summer assignments ranged from writing, testing and debugging computer programs to assisting with synthesis of new dopants in polystyrene for use in fiber detectors.

The Summer Institute for Science and Mathematics Teachers brings 45 high school science teachers in biology, chemistry and physics and 15 high school mathematics teachers to the Laboratory for an intensive four-week program. Lecture sessions in the four disciplines are conducted on Monday, Wednesday and Friday mornings by Fermilab physicists and college faculty. On Tuesday and Thursday mornings, plenary sessions are held with nationally-

known experts lecturing on interdisciplinary science topics. In the afternoon, computer instruction, lab sessions and mathematics sessions with master teachers are held at Naperville Central High School. A follow-up session is held in each discipline during the academic year following the Institute.

The 1990 Institute was held from June 10 to July 6. Participants came from nine midwestern states including Illinois, Iowa, Minnesota, Wisconsin, Michigan, Ohio, Indiana, Kentucky and Missouri. Residential participants stayed at the Iroquois Club apartments in Naperville.

A similar three-week institute, the **Chicago Summer Institute for Science and Mathematics Teachers**, was held at Chicago State University from June 25 to July 13. Sixty teachers represented 39 city high schools. Four follow-up meetings are scheduled during the school year for these participants.

"A dynamic, never-stop inspiration for science teachers. It would have been impossible to have spent these four weeks without getting excited about teaching science. Of all the classes and workshops I' ve ever taken, I can truly say this one was worth every minute!"

The Summer Science Project brings 45 junior high school science teachers to Fermilab for an intensive three-week institute. The institute curriculum includes seminars on basic science, training sessions on sound science instruction and inservice techniques, laboratory sessions where participants try out hands-on classroom activities and tours. Follow-up activities include quarterly meetings and participation in a network with teachers trained at other DOE laboratories collaborating on the project.

The 1990 program was held from July 29 to August 17. The busy schedule for these participants included a wide range of hands-on activities such as toys in space, holograms, polymer chemistry, robotics and computer applications. The group visited the Fermilab Magnet Factory, Cernan Space Center, Amoco Lasers and Research facilities, Ryndak-River Trails Nature Center, the Fermilab prairie, the University of Illinois Animal Research Labs, Argonne National Laboratory and SciTech Museum. Each participant developed a project to inservice other teachers during the school year.

Teaching Integrated Mathematics and Science (TIMS) is a three-year program for 39 elementary and junior high school teachers from nine school districts and one private school in DuPage and Kane counties. The workshop curriculum includes seminars to update participants' knowledge of basic science, and laboratory sessions to try out TIMS classroom activities. Follow-up meetings are held during the school year. The Fermilab Outreach Coordinator will visit teachers in their classrooms to assess and assist with implementation. Teachers will receive further training during the second summer to prepare them to train other teachers in their districts.

Districts participating in the 1990 program held July 9 -20 include: Batavia District 101, Benjamin District 25, Community District 180, Darien District 61, Elgin District U-46, Elmhurst District 205, Geneva District 304, Lombard District 44, West Aurora District 139 and the Rockford Diocese.

When Fermilab began sponsoring precollege education programs in 1983, it was not at all clear that a research laboratory was an appropriate setting for

major teacher institutes. Teachers have given us the answer, "Yes!" A national laboratory like Fermilab can make a significant contribution to the enhancement of science and mathematics education. Our experience has shown that although our Laboratory is a single purpose institution, teachers from all disciplines can enjoy and benefit from science and mathematics programs held here. Finally, we have shown that teachers respond positively to being treated as professionals and peers by researchers. All were honored to be involved in a program at Fermilab!

The 1990 summer programs were funded by the Department of Energy Office of Energy Research, The National Science Foundation, the Illinois State Department of Education, the Forest Fund, the Grainger Foundation, Inc., the (H. Earl) Hoover Foundation and the Robert R. McCormick Charitable Trust.

August 24, 1990

John Peoples,

I really appreciated all you did for us at Fermilab. I really enjoyed myself. Fermilab made us feel welcomed. All the people were kind to us. You let us experiment and explore there. I learned a lot and will never forget this great experience. Thanks for your hospitality.

Sincerely,
Misty VanConant

A letter written by an EAL student.

The ACP/R3000 Project
Computer R&D Department & LAFEX/CBPF Cooperate

by *Joe Biel and Roy Rubinstein*

Tom Nash (Head, Computing Division), Joe Biel (Head, Computer R & D Department) and Alberto Santoro (Head, LAFEX/CBPF) observe as Carla De Barros (member of the LAFEX/CBPF group) demonstrates one of the ACP/R3000 modules.

For about a decade, Fermilab has had a program of assisting the growth of Latin American physics, and particularly (in keeping with the Laboratory's mission) of stimulating the growth of high energy physics in the region. Over that period, the Laboratory has helped in the formation of experimental high energy physics groups in Brazil, Colombia and Mexico, and assisted activities by individual physicists in Argentina and Ecuador. The largest Latin American group is currently that led by Professor Alberto Santoro at Centro Brasileiro de Pesquisas Fisicas (CBPF) in Rio de Janeiro, Brazil. This group, which now consists of about 40 people, has taken part in 3 Fermilab experiments (E691, E769 and E791). They have created a laboratory inside CBPF called Laboratorio de Fisica Experimental de Altas Energias (LAFEX).

As a complement to its high energy physics program, the LAFEX/CBPF group has been active in using and developing the Fermilab Advanced Computer Program (ACP) system. For many years now, LAFEX/CBPF has been working closely with Fermilab's Computer Research and Development Department (and its predecessor, the Advanced Computer Program). The contribution

made by LAFEX/CBPF has grown over the years. At the beginning, the LAFEX/CBPF group successfully copied the ACP hardware and software developed at Fermilab and brought it to their institution in Brazil. More recently, its involvement has become more substantial. In particular, members of LAFEX/CBPF played key roles in designing and writing the Cooperative Processes Software (CPS) in use at Fermilab and elsewhere: this is a successor to the ACP software used on the ACP processor farms. The LAFEX/CBPF group's ACP system in Rio de Janeiro has been used by other institutions, universities, basic research institutes and other branches of physics in Brazil. It has enhanced the reputation of Fermilab there, and is an excellent example of technology transfer from high energy physics to other fields.

The system has proved to be very valuable to the Rio high energy physics community, and allows analysis to be performed there which otherwise could only take place in the United States. This is of obvious advantage to the physicists and students involved. In addition, several engineering and theoretical physics students from Rio area universities have written theses based on work using this system.

The Fermilab Computer R&D Department and the LAFEX/CBPF group are now cooperating on the completion of the ACP/3000 project. This project was started several years ago at Fermilab to provide an upgrade for the successful ACP multiprocessor system. A new computer module, called the ACP/R3000 with approximately twenty times the power of the original ACP module, has been designed and constructed. The module is based on the 25 MHz version of the R3000 microprocessor from MIPS Computer Systems, Incorporated. The R3000 microprocessor is a popular example of the new generation of Reduced Instruction Set Computer (RISC) chips. RISC chips have provided a great reduction in the price of doing computing. The LAFEX/CBPF group has already made important contributions to the porting of UNIX to the ACP/R3000 module. It has acquired the expertise needed to test and maintain a multiprocessor system constructed from ACP/R3000 modules, and is now in an excellent position to provide hardware and software support for a project involving the ACP/R3000 and UNIX.

The next step in the ACP/R3000 project is to construct a farm of the processors for use by physicists. It has been decided that a farm of 50 processors will be assigned to experiment E791 for its event reconstruction. Further, it has been decided that LAFEX/CBPF will take a leadership role in constructing and supporting this farm—a task for which it is very well qualified. LAFEX/CBPF will support not only the construction, testing and integration of the ACP/R3000 farm hardware, but will also complete the porting of UNIX to the ACP/R3000 and provide support for the Cooperative Processes Software on the farm. The Computer R&D Department will provide technical assistance for LAFEX/CBPF, but the latter has primary responsibility for making the project work.

The contribution to the farm construction and operation project by LAFEX/CBPF comes at a very critical time. The Computer R&D Department has, with the combined needs of the ACP/R3000 project and the ACPMAPS super computer project, found itself short handed. The additional skilled engineering talent provided by LAFEX/CBPF has made it possible to continue a strong effort on both projects to get them completed in a reasonable length of time. In exchange for taking on a greater degree of responsibility on the ACP/R3000 project, LAFEX/CBPF will get the exclusive use of the processor farm after its use by E791 has been completed. This will substantially increase the computing power available at LAFEX/CBPF and may even be the most powerful computer in Brazil for some classes of computations.

Already the collaboration between Fermilab and LAFEX/CBPF has helped the latter group make significant progress in high energy physics and its associated technologies, and has demonstrated that it is possible to work in this frontier field in a developing country such as Brazil. In addition, it is important to note the many interactions and friendships that have developed between the individuals who have taken part in this international collaboration. The new work on the ACP/R3000 project can only further such cooperation and international understanding.

Members of the LAFEX/CBPF group currently working at Fermilab are: (back row, l. to r.) Ignacio Bediaga, Isaias Costa, Alberto Reis, Roberto Valois, (front row, l. to r.) Carla De Barros, Carmen Silva, Marcelo Mendes and Sandra Amato.

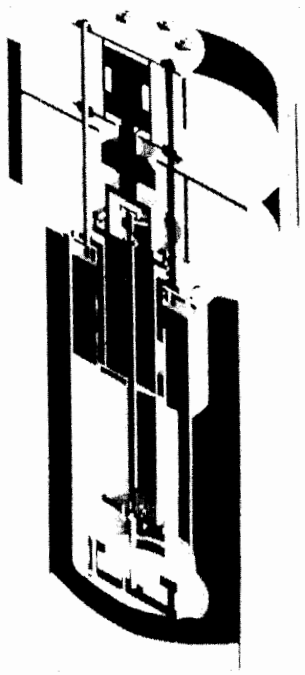
Members of the LAFEX/CBPF group in Brazil are: (l. to r.) Marcelo Nicola, Helio Da Motta Filho, Moacyr Souza, Regio Gomes, Raquel Schulze, Joao Ramos T. Mello Neto, Miriam Gandelman, Jussara Miranda, Mariano Miranda, Alberto Santoro (head), Simone Franco, Jose Guilherme Lima, Eliane, Gilvan Alves, Mario Vaz, Cicero Marques, Amilton Machado, Bruno Schulze, Jose De A. Ricardo and Joao Dos Anjos.

URA and Instron Sign Technology Licensing Agreement

by *John Venard*

Universities Research Association, Inc. (URA) has granted Instron Corporation sole commercial rights to a unique cryogenic fixture for material testing. This technology grew out of Fermilab's many years of experience working with materials and structures at cryogenic temperatures.

The URA/Instron Corporation royalty-bearing licensing agreement that became effective May 30, 1990 involves two separate pieces of technology. The first is known as the cryogenic support member and was invented by Ralph Niemann, John Gonczy and Tom Nichol. The second is the low temperature loader that was invented by Niemann and Gonczy with Finley Markley and Bill McCaw. The inventors and URA will share royalty income that results from the successful commercialization of this technology. All the inventors are, or were, members of the Technical Support Section. Ralph Niemann and John Gonczy are now at Argonne National Laboratory.



CAD-CAM representation of the Instron STET Mechanical Property Testing Fixture. *Photo courtesy of Instron Corporation.*

Flexible design applicable to many testing applications

The testing fixture, as currently designed, has a force rating of +/- 90 kN (20,000 lbs.). It can be set up for tension, tension/compression, bend or component testing. Higher force ratings can be readily achieved by increasing

the size of the load carrying members. The unique, patented joining technology developed by the Fermilab inventors allows the use of composite tubes as push/pull links within a dewar. The very low thermal conductivity of these tubes minimizes heat transfer into the cryogen. This allows relatively economical long-term operation even when using liquid helium. The commercial version of the loading fixture/dewar system will be compatible with a wide range of Instron servohydraulic and electromechanical testing machines.

Instron Corporation—A long established company in materials testing

Instron Corporation manufactures, markets and services material testing systems and accessories used to evaluate the mechanical properties and performance of plastics, metals, composites, ceramics, rubber, textiles, adhesives, wire and many other materials. Instron products are in world-wide use by research scientists, design engineers and quality control managers in industry, academia and government.

Instron Corporation was formed in 1946. In 1989, the corporations net sales were in excess of $110M. The company has design groups and manufacturing facilities in Canton, Massachusetts and High Wycombe, England.

U.S. & U.S.S.R. Collaboration in High Energy Physics

by *Roy Rubinstein*

High energy physics and international collaboration

High energy physics (HEP) experiments are carried out by university professors and their students at accelerators, large central facilities at government-funded national laboratories. There are a limited number of such HEP facilities in the world, due to their large cost. Fermilab, as an example, cost about one quarter of a billion dollars 20 years ago. An experiment is conducted at the accelerator that best suits that particular experiment, in whichever country that accelerator is located. Some years ago, the directors of the major HEP laboratories issued a statement that the criteria for acceptance of a research proposal are the scientific merit and technical competence of the proposal; note that there is no mention of the country of origin of the experimenters.

The size of research groups varies from one or two people to about 300 scientists, together with engineers and technicians, on a $100 million detector, with the experiment lasting a total of about ten years. A research group is composed of up to 30 university subgroups, each responsible for a piece of the experiment's detector or software. At Fermilab, for example, there are typically about 1,300 physicists and graduate students on our approved experiments at any time, of which some 400 are from institutions outside the U.S. representing about 20 countries. The subgroups get together to carry out an experiment because of a common interest in the physics goals. Results of the experiment are published in the open literature. These factors have historically led to collaboration among physicists from many countries.

History of U.S./U.S.S.R. collaboration in high energy physics

U.S./U.S.S.R. collaboration in high energy physics started in 1966 with the first U.S.S.R. physicist coming to work at a U.S. institution. Individual U.S. physicists visited the U.S.S.R. in the period 1970-74 , while the first U.S. group to carry out a collaborative experiment in the U.S.S.R. started its activities there

in 1970. In 1972, the first U.S.S.R. group came to the United States. Since that time, cooperation has increased each year and appears to have been unaffected by the state of political relations between the two countries.

Cooperation in high energy physics was discussed in meetings between President Dwight D. Eisenhower and Secretary Nikita Kruschev in 1955 and 1960, and led to a memorandum of understanding in 1960 between the U.S. Atomic Energy Commission and the U.S.S.R. State Committee for the Utilization of Atomic Energy. In 1973, the "Nixon-Brezhnev" agreement on cooperation in peaceful uses of atomic energy was signed. At the third meeting of the committee set up to coordinate that agreement, in 1975, there was established the U.S./U.S.S.R. Joint Coordinating Committee for Research on the Fundamental Properties of Matter (JCC-FPM). The JCC-FPM meets each year, alternately in the U.S. and the U.S.S.R., with about ten delegates from each country. On the U.S. side are representatives from universities and national labs active in high energy physics, with organization and the chairman of the delegation coming from the U.S. Department of Energy.

Representatives at the annual JCC-FPM meetings discuss the collaboration for the forthcoming year and produce a record containing the agreements reached on the numbers and duration of the planned visits for the collaborative research projects. As an example, at the 1990 meeting held at Fermilab, the plans for 1991 contained 1,445 man-weeks of U.S.S.R. physicist time in the U.S. (of which 770 will be at Fermilab), and 532 man-weeks for U.S. physicists in the U.S.S.R. These numbers are a guide to activities between the sending and receiving institutions. Generally, the time spent by U.S.S.R. physicists in the U.S. is significantly higher than that of the time spent by U.S. physicists in the U.S.S.R.; a major reason is that at the present time, the highest energy accelerators and thus the forefront activities of the field, are in the U.S.

U.S./U.S.S.R. collaboration activities at Fermilab

Fermilab has had a tradition of extensive collaboration with U.S.S.R. physicists since its experimental program started in 1972; in fact, the first experiments using the Fermilab accelerator were U.S./U.S.S.R. collaborations. Out

of a total of 388 approved experiments at the Laboratory, 28 have had physicists from U.S.S.R. institutions, involving a total of 137 U.S.S.R. physicists; on seven of the experiments, the spokesperson (senior physicist on the experiment) was from the U.S.S.R. At any given time, there have been an average of around ten U.S.S.R. physicists at Fermilab, with the numbers depending on the details of the Laboratory experiment schedule.

The physicists stay at the Laboratory for periods of time ranging from one day to two years; for the longer stays, they are frequently accompanied by their spouses and younger children. Generally, they stay in housing on the Fermilab site or in the nearby communities, identically to other visiting physicists and their families. Since 1972, over 400 U.S.S.R. visitors have been at the Laboratory, some having made several visits. As an illustration of the extent of Fermilab's U.S.S.R. activity, the table on page 27 shows the U.S.S.R. visits to the Laboratory that have been made, or are currently expected, in 1990 alone. The total is over 100. It is instructive to note that U.S.S.R. participation at Fermilab cuts through a wide variety of the Laboratory's HEP activities, from fixed-target and collider physics, through accelerator physics, to theoretical physics and astrophysics.

Experiences, benefits, prospects

What has the U.S.S.R. gained by this collaboration? A major gain has been the opportunity for U.S.S.R. physicists to carry out physics research at the highest energy accelerators in the world. These are currently are in the United States. The scientists gain some view of U.S. technology, although that can be obtained at other major laboratories in Western Europe and Japan. They also see U.S. management techniques, style of working and reduced bureaucracy compared to conditions in their own country.

What has the U.S. gained by this collaboration? Many excellent U.S.S.R. physicists have worked on experiments here, helping to further the field and interacting with our own physicists. The U.S. has had the use of new and novel equipment invented in the U.S.S.R.; two examples are a hydrogen gas jet target, which was the central component of the first Fermilab physics experi-

ments; and a lithium gas lens essential for antiproton production for the Fermilab Collider.

The U.S.S.R. physicists bring with them state-of-the-art equipment built in their laboratories, which would otherwise have to be purchased with U.S. funds. In 1984, for example, there was over $5 million worth of such equipment at Fermilab; in 1991, the amount is expected to be greater. Obviously, we gain some view of the state of U.S.S.R. technology.

Mutual benefits and prospects are many, and are to be found primarily (but certainly not exclusively) on the human level, which can only be helpful to relations between the two countries. Contacts made in joint efforts often lead to close friendships. U.S. scientists become better informed on life and attitudes in the U.S.S.R.; likewise, U.S.S.R. scientists (and their families) experience U.S. life firsthand, and return to presumable tell their colleagues.

Obviously, there are small problems in activities of this nature, but they are not severe enough to have significant impact. The exchanges tend to be a little more formal than necessary, which probably stems from the needs of the U.S.S.R. bureaucracy. Also, most U.S. physicists find travel and living in the U.S.S.R. more difficult than they are used to in the U.S. or Western Europe. In spite of the negatives, over the years, the collaboration has been growing, and all indication are that it will continue to grow; the consensus is that it is very beneficial to both sides.

Members of the U.S./U.S.S.R. Joint Coordinating Committee for Research on the Fundamental Properties of Matter at the 13th meeting held at Fermilab, October 25-26, 1990 are: (front row, l. to r.) P.V. Bogdanov (U.S.S.R., Ministry of Atomic Power and Industry); A. N. Skrinsky (U.S.S.R., Director of Institute of Nuclear Physics, Novosibirsk); A. A. Vassiliev (U.S.S.R., Head of Nuclear Physics and Controlled Fusion, Ministry of Atomic Power and Industry, Co-chair of JCC-FPM); W. N. Hess (Director of Office of High Energy and Nuclear Physics, DOE, Co-chair of JCC-FPM); J. Peoples (Director of Fermi National Accelerator Laboratory); N. Samios (Director of Brookhaven National Laboratory); (back row, l. to r.) A. V. Pavlov (U.S.S.R., Ministry of Atomic Power and Industry); V. A. Nazarenko (U.S.S.R., Deputy Director of Leningrad Nuclear Physics Institute); V. Matveev (U.S.S.R., Director of Institute for Nuclear Research, U.S.S.R. Academy of Sciences); A. Ts. Amatuni (U.S.S.R. Director of Yerevan Physics Institute); I. V. Chuvilo (U.S.S.R., Director of Institute of Theoretical and Experimental Physics); V. A. Yarba (U.S.S.R., Deputy Director of Institute of High Energy Physics); R. Rubinstein (Fermi National Accelerator Laboratory); T. Toohig (Superconducting Super Collider Laboratory); P. K. Williams (DOE); K. Strauch (Harvard University); D. Lowenstein (Brookhaven National Laboratory); D. Leith (Stanford Linear Accelerator Laboratory) and H. Grunder (Director of Continuous Electron Beam Accelerator Facility). Not pictured are: D. K. Stevens (Director of the Office of Basic Energy Sciences, DOE); E. Knapp (Director of LAMPF, Los Alamos National Laboratory) and J. R. O'Fallon (Director of the Division of High Energy Physics, DOE).

U.S.S.R. Visitors to Fermilab in 1990

Visitors	Institution	Collective Length of Stay (Wks)
E704		
12	IHEP	241
1	JINR	1
DØ		
25	IHEP	233
1	Moscow State University	1
E672		
14	IHEP	126
1	Moscow State University	26
E761		
1	ITEP	8
10	LNPI	277
Accelerator		
7	IHEP	34
Theory/Astrophysics		
1	LNPI	4
1	ITP Kiev	7
1	ERPI	9
1	Lebedev	3 days
2	JINR	2
1	ITP Moscow	1 day
1	INR	3 days
Miscellaneous		
16	Min. At. Pwr. & Ind.	2 wks, 2 days
12	LNPI	3
2	IHEP	5
3	JINR	3
1	ITEP	1
1	Efremov Inst.	1 day
1	Kurchatov	1 day

Fermilab Scientist Directs New Science Center

Ernest Malamud, a senior scientist at Fermilab, was granted a sabbatical leave by the Universities Research Association, Inc., the corporation that manages Fermilab. This leave will free most of Dr. Malamud's time to enable him to be the full-time director of SciTech, an interactive science and technology museum serving the Chicagoland western suburban area.

Ernest Malamud, Director of SciTech, views tornado display with visiting students. The tornado was built by Todd and Mary Lynn Johnson. Todd is a Fermilab accelerator operations crew chief.

SciTech, the brainchild of Dr. Malamud, is an initiative to counteract the crisis in science literacy in America by using hands-on exhibits to stimulate children's interest in science and math. "No one flunks museum," Frank Oppenheimer once wrote and according to physicist Ernest Malamud, "Museums offer an unhurried and deliberate glimpse into the many wonders of our modern world— wonders otherwise inaccessible to the average person." So it is at SciTech, where exhibits create understanding out of scientific and technological complexity.

SciTech is one of only a handful of museums of its kind and its uniqueness lies in that it was developed and nurtured by the scientific community rather than being designed and developed by traditional museum curators. Relying upon the expertise of a cadre of high-tech volunteers to build and design the exhibits and displays that address issues in modern science, Malamud and his wife

Olivia Diaz, who serves as president of the board of directors, have developed SciTech very rapidly over a two-year period with a very small budget. "The role of the volunteers was and is crucial to the development and operation of SciTech. Many people have given of their time and there are still many opportunities for volunteers to be involved in what we think is a very exciting project," said Malamud.

SciTech opened its doors to the public on June 16 in its permanent home in the stately former Post Office building at 18 West Benton in downtown Aurora. Within a month of opening to the public, SciTech was receiving 1,500 visitors a week.

The mission

The goal of SciTech is to provide a cultural resource focusing on science and technology in a welcoming, non-threatening environment. "When visitors leave with the impression that science and technology are important and worthy of pursuit for themselves and their children, we have achieved that goal," stated the SciTech Director.

In the beginning

SciTech began in July 1987 as a discussion paper written and circulated by Ernest Malamud. In December 1987, he organized an international Experts Workshop which brought together eight museum directors and educators from the U.S., England and France. This workshop validated the need for a science center along the I-88 Research and Development Corridor and drafted parameters for the size and scope of the center.

In April 1988, a Board of Directors was formed and SciTech was incorporated on June 17, 1988. A corp of volunteers constructed the first set of 25 exhibits and a Public Introduction was held in August at Illinois Benedictine College. Immediately following the the one-day show, some of the hands-on exhibits went on display at the DuPage County Center for 5 months. In December 1988, a temporary home of 7,000 square feet in Naperville was donated by Fred Barofsky and Associates through February 1990.

In January 1989, tax deductible status was granted by the IRS. The same year, SciTech doubled the number of its exhibits and opened regular, though limited hours, staffed by volunteers. A grant from WMI Environmental Monitoring Laboratories enabled SciTech to hire its first employee in October 1989. By the end of its first year of open hours, the exhibits had been seen by over 20,000 visitors.

NSF funds *Building Blocks of the Universe* exhibition

The National Science Foundation granted nearly $250,000 to a joint venture by SciTech and COSI (Ohio's Center of Science and Industry). The funds will be used to create *Building Blocks of the Universe*, an exhibition designed to explore fundamental aspects of the universe as revealed by nuclear and particle physics. "The grant is considered to be significant," said Malamud, "and of a magnitude usually reserved for projects advanced by well-established museums." Most museums have not made nuclear and sub-nuclear physics the subject of a major exhibit. Charles O'Connor, Executive Vice President of COSI and Malamud feel it is time to use hands-on exhibits to impart these basically simple, but far-reaching, ideas to the science center audience.

The vision

The I-88 Corridor has concentrated an usually large pool of scientifically and technically talented people in one geographic area. The vision of SciTech is to bring these resources to bear on the problem of the crisis in science literacy facing America today. The vision is to provide a place where the passion and devotion to science of the scientific and technical community can be expressed to children through the medium of simple, interactive exhibits that will communicate to them the wonder, power and unity of science.

While there are over 300 interactive science centers around the world, SciTech is unusual in that its director is a scientist. Through his leadership, SciTech has been successful in tapping the resources, creative energy and love of science of those employed by the research and development companies along the Corridor to develop original exhibits to explain complex scientific and technical subjects.

Changes at the Fermilab Library

By *David Ritchie and Paula Garrett*

What happened to the card catalog?

Recent visitors to the Fermilab Library may have noticed that the Card Catalog has now turned into a stand for a computer terminal. During the summer the catalog function was turned over to an online catalog query program provided by the Library's new automation system. The online catalog milestone was reached after a year's activity of installing the automation system and converting the catalog information from card to disk format.

May West (l.) and Lee Robbins (r.) of the Fermilab Library staff use the new library automation system to process the day's book returns.

This accomplishment is due to the Laboratory's purchase of a full-fledged library automation system from Data Research Associates, Inc. (DRA) of St. Louis, Missouri. The system runs under VMS on a MicroVAX 3400 which was also purchased as part of the automation project. System backup is provided by an eight millimeter, camcorder-style, tape drive. Thus, the automation project was able to take advantage of technological spin-off from Fermilab's experimental program which pushed to acquire the inexpensive, high capacity tape storage devices to do online data recording.

The change in the catalog capabilities is more than a simple replacement. For example, you no longer need to go to the Library to access the catalog. You can instead get to it from your office terminal* over the network that links the laboratory computers. Also, the online version provides a much more extensive search capability—you can look up a book by any word in its title, author, or Library of Congress subject heading—not just by the first word. In addition, searches by combinations of words via logical AND's, OR's, NOT's, etc. are possible. Finally, the catalog provides an indication of whether or not the book is on the shelf, due dates if not, and the capability to request a hold under your Fermilab or Visitor ID.

Book overdue notice—What's this?

Recently, you may have received a book overdue notice. Over the summer, the Library began using the automation system to track circulation and to print overdue notices. This circulation milestone was reached after the necessary programming was completed to perform a regular download to the library system of employee/visitor information from Fermilab's online telephone book—the latter is itself updated from the Laboratory employee and visitor databases.

As with the online catalog, the changes to the circulation procedures are more than a simple replacement. Before, only the sending of occasional overdue notices was possible. Now, the automation system provides a regular sending of printed notices. The positive effect has been the increased availability of the Library's collection. Books have been returned from as far away as Ohio (by Federal Express, even) and, in some cases, have been returned after being out for as long as two years.

* To try out the online catalog from any VAX VMS system on the Laboratory network, do "$ SET HOST FNLIB" and provide "LIBRARY" in response to the Username prompt. Contact the Library to obtain an information sheet concerning access via Internet or via the Port Selector directly.

The additional statistics provided by the automated circulation reports have already provided some interesting information. For example, during the month of October 1990, about 7% of the Library's collection was checked out. The statistics also showed an increase of about 0.7% due to the purchase of new items. The "instrumentation" of the collection and the circulation activity in this way allows the Library to improve the collection in a targeted and managed fashion. Recently, for example, additional copies of several books were purchased because the reports showed that all available copies were checked out and that there were outstanding requests for them as well.

What's in and what's not?

At this time, not all of the Library's collections are listed in the online catalog. Included are the Main, Reference and Locked Case collections. Not included at this time are the preprints, journals, Fermilab FN's and TM's, Fermilab proposals, Ph.D. theses for Fermilab experiments, audio/video tapes, and other materials, such as the SSC site studies.

What are the future plans?

Future plans are to include additional collections, to bring up additional automation system modules, and to further enhance automation services.

The list, given above, of collections not yet in the system is the expected order of collection implementation. Work is proceeding on adding the preprints. When completed, the functionality present for books (online catalog, circulation, requests, etc.) will become available for preprints.

Still to be brought up are the acquisitions and serials modules. Acquisitions will result in "on-order" book information being present in the online catalog. Serials will add to the online catalog information on the journals held by the library and details on which issues have been received. Behind the scenes, both of these modules will aid the library staff in tracking spending and subscription-receipt status.

Some future enhancements are the delivery of notices via electronic mail, the automation of patron self-checkout, and the use of the system's ability to incorporate the online catalogs of other similarly networked libraries. From the patron's point of view, the latter will make it easier for the patron to identify relevant materials not held by the Fermilab Library but which can be obtained through the Fermilab Library's interlibrary loan services.

Who's responsible for all this?

The Library Automation Project began during the tenure of of Leon Lederman as Director and Hank Thacker as Chair of the Fermilab Library Committee. The automation subcommittee of the Library committee, consisting of Paula Garrett and David Ritchie, researched and presented the candidate systems to the Library Committee which approved the DRA choice.

The automation project has continued to be an important priority under the leadership of Director John Peoples and Fermilab Library Committee Chair Stephen Parke. As a part of Laboratory Services, the Library has received the support of Chuck Marofske, Head, Laboratory Services in this effort. The project has been supported during the implementation phase by David Ritchie of the Fermilab Computing Division under the leadership of Tom Nash.

May West, Lee Robbins, and Angie Penson of the Library staff have spear-headed the conversion of the old manual procedures to the new automated ones. Students working towards their Masters Degree in Library Science at Northern Illinois University under Professor Andrew Torok performed the barcoding of the collection.

Fermilab Recipient of Energy Management Awards

Fermi National Accelerator was chosen as the 1989 recipient of the U.S Department of Energy In-House Energy Management (IHEM) Program award for the **Best Energy Management Program at a Laboratory.** This award was conferred in recognition of Fermilab's "extraordinary achievements, initiatives and resourcefulness in planning and implementing a highly effective energy management program."

The award was presented by J. Michael Davis, Assistant Secretary for Conservation and Renewable Energy and accepted by Dennis Theriot, Directorate, on October 26 at the Eleventh Annual In-House Energy Management Awards Ceremony held at Forrestal Auditorium in Washington, D.C.

William Riches (r.) accepts the 1990 Association of Energy Engineers Regional Engineer of the Year award at Argonne National Laboratory on October 25, 1990. Bill passed away on October 28, 1990.

Actions taken at Fermilab during FY 1989 to improve energy efficiency included: lighting retrofits and controls, gradual conversion to energy efficient fluorescent lamps and ballasts, accelerator operating control revisions to reduce electromagnet power levels during periods when no proton beam is being accelerated, conversion from electric to natural gas heating, installation

of winter time "free" water cooling heat exchangers, and an upgraded energy awareness and employee cash award incentive program.

During FY 1989, the Lab reduced energy consumption per square foot from the FY 1985 base-year by 5% in buildings and by 36% in metered processes. Energy consumption in vehicles and equipment was reduced by 22%.

According to Davis, "Fermilab's achievements, which includes consumption decreases in excess of 10%, contributed significantly to the Department of Energy's energy reduction goal of 10% by FY 1995."

Fermilab was also chosen as the recipient of the 1990 Association of Energy Engineers (AEE) Energy Efficiency Corporate Award, which was awarded on October 25 at DOE/Argonne National Laboratory. At the same ceremony, William Riches, Fermilab's In-house Energy Management Engineer was honored as the recipient of the 1990 AEE Award as Regional Engineer of the Year.

Staff Physicists Elected to APS Fellowship

Charles Brown

H. Eugene Fisk

Donald Young

Charles Brown (Physics Section), H. Eugene Fisk (Research Division/DØ Construction Department) and Donald Young (Accelerator Division/Linac) have been accepted to Fellowship in the American Physical Society (APS). Their names and citations will be published in the February 1991 *Bulletin of the American Physical Society*.

Only members of the American Physical Society who have contributed to the advancement of physics through independent, original research, or who have rendered some other special service to the cause of the sciences are elected into fellowship.

Charles Brown was cited by APS "for his leadership in a series of experiments studying dimuon production by high energy hadrons." H. Eugene Fisk's citation stated, "for his leadership in neutrino physics research, and his skilled management of large scientific projects including superconducting high-gradient quadrupoles and Fermilab's DØ detector." Donald Young was elected to Fellowship "for contributions to the science of linear accelerators including the development of computer programs for RF fields and beam dynamics in accelerating structures, thereby advancing their design and construction."

Publications

Experimental Physics Results

Experiment 605
Moreno, G. et al. "Dimuon Production in Proton-Copper Collisions at $\sqrt{s}$=38.8 GeV." (FERMILAB-Pub-90/223-E) Submitted to *Phys. Rev. D.*

Experiment 687
Buchholz, D. "Photoproduction of D Mesons." (FN-555) Presented at the XXVth International Conference on High Energy Physics, Kent Ridge, Singapore, August 2-8, 1990.

Frabetti, P. L. et al. "Measurement of the Λ_c^+ and D_s^+ Lifetimes." (FERMILAB-Pub-90/158-E) Submitted to *Phys. Lett. B.*

Lingel, K. L. "Photoproduction of $D^\pm$ Mesons." Ph.D. Thesis, University of Illinois at Urbana-Champaign, Urbana, Illinois, 1990.

Shephard, W.D. "Some Lifetimes and Branching Ratios for Charmed Hadrons Produced in the Fermilab Wide-Band Photon Beam." (FN-557) Presented at the XXVth International Conference on High Energy Physics, Kent Ridge, Singapore, August 2-8, 1990.

Experiment 691
Anjos, J. C. et al. "Some Cabibbo-Suppressed Decays of the D^0 Meson." (FERMILAB-Pub-90/183-E) Submitted to *Phys. Rev. Rapid Commun.*

Experiment 710
Rubinstein, R. "Total, Elastic and Diffractive Cross Sections at High Energies." (FERMILAB-Conf-90/160-E) Talk given at the Xth International Conference on Physics in Collision, Durham, North Carolina, June 21-23, 1990.

Experiment 711

Boca, G. et al. "Average Fraction of Jet Momentum Carried by High $P_\perp$ Leading Hadrons." (FERMILAB-Pub-90/148-E) Submitted to *Z. Phys. C.*

Experiment 731

Hsiung, Y. B. "CP Violation Experiment at Fermilab." (FERMILAB-Conf-90/163-E) Talk given at the Second International Conference on Medium- and High-Energy Nuclear Physics, Taipei, Taiwan, May 14-18, 1990.

Experiment 733

Strongin, B. "Opposite Sign Dimuon Production in High Energy Neutrino-Nucleon Interactions." Ph.D. Thesis, Massachusetts Institute of Technology, Cambridge, Massachusetts, May 1989.

Experiment 735

Anderson, E. W. et al. "A Scintillator Hodoscope at the Tevatron Collider." (FERMILAB-Pub-90/152-E) Submitted to *Nucl. Instrum. Methods A.*

Turkot, F. "A Quark-Gluon Plasma Search in $\bar{p}$-p at $\sqrt{s}$=1.8 TeV." (FERMILAB-Conf-90/205-E) Presented at the Quark Matter '90 Conference, Menton, France, May 7-11, 1990.

Experiment 741/CDF

Abe, F. et al. "A Measurement of the W-Boson Mass." (FERMILAB-Pub-90/161-E) Submitted to *Phys. Rev. Lett.*

Abe, F. et al. "A Measurement of the W Boson Mass in 1.8 TeV $\bar{p}p$ Collisions." (FERMILAB-Pub-90/162-E) Submitted to *Phys. Rev. D.*

Abe, F. et al. "Top Quark Search in the Electron + Jets Channel in Proton-Antiproton Collisions at $\sqrt{s}$ = 1.8 TeV." (FERMILAB-Pub-90/137-E) Submitted to *Phys. Rev. D.*

Beretvas, A. "Limits on the Masses of Supersymmetric Particles from 1.8 TeV $\bar{p}$-p Collisions." (FERMILAB-Conf-90/221-E) Presented at the 1990 Summer Study on High Energy Physics, *Research Directions for the Decade*, Snowmass, Colorado, June 25 - July 13, 1990.

Contreras, M. "Search for the Top Quark and Other New Particles at $p\bar{p}$ Colliders." (FERMILAB-Conf-90/165-E) Presented at the Xth International Conference on Physics in Collision, Durham, North Carolina, June 21-23, 1990.

Derwent, P. F. "A Measurement of $\sigma(W \rightarrow e\,\nu)$ and $\sigma(Z^0 \rightarrow e^+e^-)$ in $\bar{p}p$ Collisions at $\sqrt{s}$=1800 GeV." Ph.D. Thesis, University of Chicago, Chicago, Illinois, December 1990.

Flaugher, B. L. "Measurement of QCD Jet Broadening in $p\bar{p}$ Collisions at $\sqrt{s}$=1.8 Tev." Ph.D. Thesis, Rutgers, The State University of New Jersey, New Brunswick, New Jersey, October 1989.

Flaugher, B. L. "QCD Studies at the Hadron Colliders." (FERMILAB-Conf-90/159-E) Presented at the Xth International Conference on Physics in Collision, Durham, North Carolina, June 21-23, 1990.

Geer, S. "Recent Results from Proton-Antiproton Colliders." (FERMILAB-Conf-90/146-E) Review talk at the First International Symposium on Particles, Strings and Cosmology, Boston, Massachusetts, March 27-31, 1990.

Grosso-Pilcher, C. and White, S. "CDF Luminosity Calibration." (FN-550).

Hu, P. "Search for Supersymmetric Particles in $p\bar{p}$ Collisions at $\sqrt{s}$=1.8 TeV." Ph.D. Thesis, Rutgers, The State University of New Jersey, New Brunswick, New Jersey, June 1990.

Keutelian, H. "Measurement of the Mass and Width of the Z Boson from $Z \rightarrow e^+e^-$ Decay in $\bar{p}p$ Collisions at the $\sqrt{s}$=1.8 TeV." Ph.D. Thesis, University of Illinois at Urbana-Champaign, Urbana, Illinois, 1990.

Kim, S. "Electron Identification at CDF." (FERMILAB-Conf-90/139-E) To be published in the proceedings of the International Workshop on Solenoidal Detectors for the SSC, Tsukuba, Japan, April 23-25, 1990.

Plunkett, R. "Jet Dynamics at the Tevatron Collider." (FERMILAB-Conf-89/261-E) Published in the proceedings of the 8th Topical Workshop on $p\bar{p}$ Collider Physics, Castiglione della Pescaia, Italy, September 1-5, 1989.

Rimondi, F. "Multifractal Structures in Multiparticle Production in $\bar{p}$-p Interactions at $\sqrt{s}$=1800 GeV." (FERMILAB-Conf-90/166-E) Invited talk presented at the International Workshop on Correlations and Multiparticle Production, Marburg, Germany, May 14-16, 1990.

Schlabach, P. "W Mass Measurement with Muons at $\sqrt{s}$=1.8 TeV." Ph.D. Thesis, University of Illinois at Urbana-Champaign, Urbana, Illinois, 1990.

Smith, D. A. "Study of Muons Associated with Jets in Proton-Antiproton Collisions at $\sqrt{s}$=1.8 TeV." Ph.D. Thesis, University of Illinois at Urbana-Champaign, Urbana, Illinois, 1989.

Yeh, G. P. "Top Quark and SUSY Searches at CDF." (FERMILAB-Conf-90/138-E) To be published in the proceedings of the Les Rencontres de Physique de la Vallee D'Aosta, LaThuile, Italy, March 18-24, 1990.

Yun, J. C. "Recent QCD Results from CDF." (FERMILAB-Conf-90/220-E) Presented at the QCD Workshop 1990: QCD 90, Montpellier, France, July 8-13, 1990.

Experiment 760

Bartoszek, L. et al. "The E760 Lead-Glass Central Calorimeter: Design and Initial Test Results." (FERMILAB-Pub-90/190-E) Submitted to *Nucl. Instrum. Methods A.*

Experiment 772

Alde, D. M. et al. "The A-Dependence of J/ψ and ψ' Production at 800 GeV/c." (FERMILAB-Pub-90/156-E) Submitted to *Phys. Rev. Lett.*

General Particle Physics

Amos, N. A., Bross, A. D. and Lundin, M. C. "Optical Attenuation Length Measurements of Scintillating Fibers." (FERMILAB-Pub-90/150) Submitted to *Nucl. Instrum. Methods A.*

Appel, J. A. "Heavy Flavor Production in Fixed-Target Experiments." (FERMILAB-Conf-90/173) Presented at the Xth International Conference on Physics in Collision, Durham, North Carolina, June 21-23, 1990.

Bossert, R. C. and Kerby, J. S. "Mechanical Support of Superconducting Coils." (TM-1674) Presented at *Physics at Fermilab in the 1990s*, Breckenridge, Colorado, August 15-24, 1989.

Bross, A. D. and Pla-Dalmau, A. "Radiation-Induced Hidden Absorption Effects in Polystyrene Based Plastic Scintillator." (FERMILAB-Pub-90/224) To be published in the American Chemical Society Symposium Series, 1990.

Gourlay, S. A. et al. "Degradation Studies of Fermilab Low Beta Quadrupole Cable." (TM-1687) Presented at the 1990 Applied Superconductivity Conference, Snowmass, Colorado, September 24-28, 1990.

Green, D. "Dijet Spectroscopy at High Luminosity." (FERMILAB-Conf-90/151) Presented at the 1990 DPF Summer Study on High Energy Physics, Snowmass, Colorado, June 25 - July 13, 1990.

Green, D. "Gravity for the Masses." (FN-549) Academic lectures presented at Fermi National Accelerator Laboratory, Batavia, Illinois, January 22 - February 2, 1990.

Hoeneisen, B., Anderson, D. F. and Kwan, S. "A CsI-TMAE Photocathode with Low-Pressure Readout for RICH." (FERMILAB-Pub-90/182) Submitted to *Nucl. Instrum. Methods A*.

Lipski, A., Carson, J. A. and Robotham, W. F. "SSC Dipole Magnet Measurement and Alignment Using Laser Technology." (TM-1671[SSCL-N-731]) Presented at the 1990 International Industrial Symposium on the Super Collider (IISSC), Miami Beach, Florida, March 14-16, 1990.

McInturff, A. D. et al. "Ternary Superconductor 'NbTiTa' for High Field Superfluid Magnets." (TM-1672) Submitted to the Intermag 90: International Magnetics Conference, Brighton, England, April 17-20, 1990.

Morfín, J. G. "A Global Analysis of Recent Experimental Results: How Well Determined are the Parton Distribution Functions?" (FERMILAB-Conf-90/155) Presented at the Workshop on Hadron Structure Functions and Parton Distributions, Batavia, Illinois, April 26-28, 1990.

Stanfield, K. C. "Fermilab Physics Program for the 1990's." (TM-1697) Presented at the Second International Conference on Medium- and High-Energy Nuclear Physics, Taipei, Taiwan, May 14-18, 1990.

Van Ginneken, A. "Smoothing Algorithm for Histograms of One or More Dimensions." (FERMILAB-Pub-90/197) Submitted to *Nucl. Instrum. Methods A*.

Accelerator Physics

Bogacz, S. A. "Transition Crossing in the Main Injector – ESME Simulation." (FN-547).

Brown, B. C. "Accelerator Magnet Designs Using Superconducting Magnetic Shields." (TM-1686) Presented at the 1990 Applied Superconductivity Conference, Snowmass, Colorado, September 24-28, 1990.

Harfoush, F. A. and Jurgens, T. G. "Numerical Modeling of Time Domain 3-D Problems in Accelerator Physics." (FERMILAB-Conf-90/140) Presented at the 2nd European Particle Accelerator Conference (EPAC 90), Nice, France, June 12-16, 1990.

Jurgens, T. G. et al. "The Determination of the 805 MHz Side Coupled Cavity Dimensions for the Fermilab Linac Upgrade." (FERMILAB-Conf-90/194) Presented at the 1990 Linear Accelerator Conference, Albuquerque, New Mexico, September 10-14, 1990.

Kourbanis, I., Meisner, K. and Ng, K.-Y. "Experimental Study of the Main Ring Transition Crossing." (TM-1693) Submitted to the proceedings of the Fermilab III Instabilities Workshop, St. Charles, Illinois, June 25-29, 1990.

Kourbanis, I. and Ng, K.-Y. "Main Ring Transition Crossing Simulations." (TM-1694) Submitted to the proceedings of the Fermilab III Instabilities Workshop, St. Charles, Illinois, June 25-29, 1990.

Kuchnir, M. and Ozelis, J. P. "Superconducting Current Transducer." (TM-1688) Presented at the 1990 Applied Superconductivity Conference, Snowmass, Colorado, September 24-28, 1990.

Lee, S. Y. and Ng, K.-Y. "Longitudinal and Transverse Instabilities Around a γ_T Jump." (FN-551) Submitted to the proceedings of the Fermilab III Instabilities Workshop, St. Charles, Illinois, June 25-29, 1990.

MacLachlan, J. A., Mills, F. E. and Owens, T. "Feed-Forward Compensation for Transient Beam Loading of the 805 MHz Debuncher for the Fermilab Linac Upgrade." (FERMILAB-Conf-90/174) Presented at the 1990 Linear Accelerator Conference, Albuquerque, New Mexico, September 10-14, 1990.

May, M. P. et al. "Mechanical Construction of the 805 MHz Side-Coupled Cavities for the Fermilab Linac Upgrade." (FERMILAB-Conf-90/204) Presented at the 1990 Linear Accelerator Conference, Albuquerque, New Mexico, September 10-14, 1990.

Ng, K.-Y. "Evaluation of Wake Forces in a Dielectric-Lined Waveguide." (FN-546).

Ng, K.-Y. "Transverse Emittance Growth During γ_T Jump." (FN-552) Submitted to the proceedings of the Fermilab III Instabilities Workshop, St. Charles, Illinois, June 25-29, 1990.

Peggs, S. and Saritepe, S. "Critical Beam-Beam Resonances in the Tevatron." (FN-548).

Rosenzweig, J. B. "SUPERFLIC – A Recirculating Superconducting Linear Collider Toponium Factory." (FERMILAB-Conf-90/201) Submitted to the proceedings of the 1st Workshop on a TeV Superconducting Linear Collider, Ithaca, New York, July 23-26, 1990.

Owens, T. L. and McCrory, E. S. "The Delta-T Tuneup Procedure for the Fermilab Linac." (FERMILAB-Conf-90/207) To be published in the proceedings of the 1990 Linear Accelerator Conference, Albuquerque, New Mexico, September 10-14, 1990.

Theoretical Physics

Albright, C. H. "Top Quark Mass Spectrum from Flavor-Changing Processes." (FERMILAB-Conf-90/196-T) To appear in the proceedings of the 25th International Conference on High Energy Physics, Kent Ridge, Singapore, August 2-8, 1990.

Baur, U. and Glover, E. W. N. "Observability of a Heavy Higgs Boson at Hadron Supercolliders." (FERMILAB-Pub-90/154-T) Submitted to *Phys. Rev. Lett.*

Baur, U. and Glover, E. W. N. "Tagging the Higgs Boson in $pp \rightarrow W^+W^- jj$." (FERMILAB-Pub-90/189-T) Submitted to *Phys. Lett. B.*

Berends, F. A. et al. "On the Production of a W and Jets at Hadron Colliders." (FERMILAB-Pub-90/213-T) Submitted to *Nucl. Phys. B.*

Bern, Z. and Kosower, D. A. "Efficient Calculation of One-Loop QCD Amplitudes." (FERMILAB-Pub-90/225-T) Submitted to *Phys. Rev. Lett.*

Carena, M. et al. "Parity Breakdown and Induced Fermion Number in the O(3) Nonlinear σ Model." (FERMILAB-Pub-90/171-T) Submitted to *Phys. Lett. B.*

Chang, C.-H., Chen, Y.-Q. and Kuang, Y.-P. "Comment on the Calculations for Some Bound State Annihilation and Creation." (FERMILAB-Pub-90/180-T) Submitted to *Phys. Rev. D.*

Chang, D. "The Neutron Electric Dipole Moment and the Weinberg Mechanism." (FERMILAB-Conf-90/188-T) Report given at the 25th Rencontres de Moriond, Les Arcs, France, March 4-10, 1990.

Chang, D. and Senjanovic, G. "Neutrino Magnetic Moment." (FERMILAB-Conf-90/187-T) Report given at the 25th Rencontres de Moriond, Les Arcs, France, March 4-10, 1990.

Chaudhuri, S., Lykken, J. and Morris, T. R. "Bigeneric Nonperturbative Strings." (FERMILAB-Pub-90/168-T) Submitted to *Phys. Lett. B.*

Ellis, R. K. and Stirling, W. J. "QCD and Collider Physics." (FERMILAB-Conf-90/164-T) Based on lectures given at CERN and CERN-JINR Schools of Physics, Geneva, Switzerland, June 25 - July 8, 1990.

Golden, M. and Hill, B. "Heavy Meson Decay Constants: $1/m$ Corrections." (FERMILAB-Pub-90/216-T) Submitted to *Phys. Lett. B.*

Griffin, P. A. and Hernández, O. F. "Feigin-Fuchs Derivation of SU (1,1) Parafermion Characters." (FERMILAB-Pub-90/191-T) Submitted to *Phys. Lett. B*.

Hill, C. T., Luty, M. A. and Paschos, E. A. "Electroweak Symmetry Breaking by Fourth Generation Condensates and the Neutrino Spectrum." (FERMILAB-Pub-90/212-T) Submitted to *Phys. Rev. D*.

Hill, C. T. "Dynamical Symmetry Breaking of the Electroweak Interactions and the Renormalization Group." (FERMILAB-Conf-90/170-T) Invited talk presented at the 1990 Workshop on Dynamical Symmetry Breaking, Nagoya, Japan, July 24-27, 1990.

Hill, C. T., Steinhardt, P. J. and Turner, M. S. "Can Oscillating Physics Explain an Apparently Periodic Universe?" (FERMILAB-Pub-90/129-T) Submitted to *Nature*.

Kosower, D. A. "The Spinor Helicity Method in Dimensional Regularization." (FERMILAB-Pub-90/208-T) Submitted to *Phys. Lett. B*.

Morris, T. R. "2D Quantum Gravity, Multicritical Matter and Complex Matrices." (FERMILAB-Pub-90/136-T) Submitted to *Phys. Lett. B*.

Mukhopadhyaya, B. "Exotic Higgs Interactions and Z-Factories." (FERMILAB-Pub-90/169-T) Submitted to *Phys. Lett. B*.

Rajpoot, S. "Model with Calculable Dirac Neutrino Masses." (FERMILAB-Pub-90/175-T) Submitted to *Phys. Rev. Lett.*

Tung, W.-K. "Overview of Parton Distributions and the QCD Framework." (FERMILAB-Conf-90/172-T) To appear in the proceedings of the Workshop on Hadron Structure Functions and Parton Distributions, Batavia, IL, April 26-28, 1990.

Theoretical Astrophysics

Amsterdamski, P. "Statistics of the Gravitational Microiensing." (FERMILAB-Pub-90/222-A) Submitted to *Astrophys. J.*

Brown, L. E. "Possible Sources of the Population I Lithium Abundance and Light Element Evolution." (FERMILAB-Pub-90/203-A) Submitted to *Astrophys. J.*

Freese, K., Frieman, J. A., and Olinto, A. V. "Natural Inflation with Pseudo-Nambu-Goldstone Bosons." (FERMILAB-Pub-90/177-A) Submitted to *Phys. Rev. Lett.*

Goetz, G. and Nötzold, D. "Microwave Background Distortions from Domain Walls." (FERMILAB-Pub-90/176-A) Submitted to *Nucl. Phys. B.*

Gregory, R. "Effective Actions for Bosonic Topological Defects." (FERMILAB-Pub-90/157-A) Submitted to *Phys. Rev. D.*

Hill, C. T., Steinhardt, P. J. and Turner, M.S. "Coherent Peculiar Velocities and Periodic Red Shifts." (FERMILAB-Pub-90/193-A) Submitted to *Astrophys. J. Lett.*

Kolb, E. W. "First-Order Inflation." (FERMILAB-Conf-90/195-A) To appear in the proceedings of the Nobel Symposium #79, *The Birth and Early Evolution of the Universe*, Gräftavallen, Sweden, June 11-16, 1990.

Quashnock, J. M. and Piran, T. "Effects of Gravitational Backreaction on Small-Scale Structure of Cosmic Strings." (FERMILAB-Pub-90/179-A) Submitted to *Phys. Rev. Lett.*

Ryu, D., Frieman, J. A., and Olinto, A. V. "Galaxy Clustering in a Bubbly Universe." (FERMILAB-Pub-90/184-A) Submitted to *Astrophys. J.*

Saloped, D. S. and Bond, J. R. "Stochastic Inflation and Nonlinear Gravity." (FERMILAB-Pub-90/167-A) Submitted to *Phys. Rev. D.*

Turner, M. S. "The Best-Fit Universe." (FERMILAB-Conf-90/226-A) Presented at the Nobel Symposium #79, *The Birth and Early Evolution of the Universe*, Gräftavallen, Sweden, June 11-16, 1990.

Turner, M. S. "Dark Matter in the Universe." (FERMILAB-Conf-90/230-A) Presented at the Nobel Symposium #79, *The Birth and Early Evolution of the Universe*, Gräftavallen, Sweden, June 11-16, 1990.

Turner, M. S., Watkins, R. and Widrow, L. M. "Microwave Distortions from Collapsing Domain-Wall Bubbles." (FERMILAB-Pub-90/185-A) Submitted to *Astrophys. J. Lett.*

Turner, M. S. and Wilczek, F. "Relic Gravitational Waves and Extended Inflation." (FERMILAB-Pub-90/178-A) Submitted to *Phys. Rev. Lett.*

Turner, M. S. and Wilczek, F. "Inflationary Axion Cosmology." (FERMILAB-Pub-90/198-A) Submitted to *Phys. Rev. Lett.*

Computing

Lindsey, C. S. and Denby, B. "Primary Vertex Finding in Proton-Antiproton Events with a Neural Network." (FERMILAB-Pub-90/192) Submitted to *Nucl. Instrum. Methods A.*

Cryogenics

Fuerst, J. D. "An Investigation of Thermally Driven Acoustical Oscillations in Helium Systems." (TM-1676) Published in the proceedings of the Low Temperature Engineering and Cryogenics Conference 1990, Southampton, England, July 17-19, 1990.

Fuerst, J. D. "Trial Operation of Cold Compressors in Fermilab Satellite Refrigerators (TM-1677) Published in *Advances in Cryogenic Engineering*, Volume 35B, 1990.

Nicol, T. H. "Cryostat Design for the Superconducting Super Collider." (TM-1684[SSCL-N-738]) Presented at the ASME Winter Annual Meeting, Dallas, Texas, November 25-30, 1990.

Nicol., T. H. and Tsavalas, Y. P. "Cryostat Design for the Superconducting Super Collider 50mm Aperture Dipole Magnet." (TM-1683 [SSCL-N-737]) Presented at the 1990 Applied Superconductivity Conference, Snowmass, Colorado, September 24-28, 1990.

Other

Lennox, A. J. "Hospital-Based Proton Linear Accelerator for Particle Therapy and Radioisotope Production." (FERMILAB-Pub-90/217) Submitted to *Nucl. Instrum. Methods B*.

Pla-Dalmau, A. "Design of Fluorescent Compounds for Scintillation Detection." Ph. D. Thesis, Northern Illinois University, DeKalb, Illinois, August 1990.

Requests for publications

The publications listed in this issue of *Fermilab Report* were prepared or presented from August 1, 1990 through November 31, 1990.

Beginning with the January/February 1991 issue, *Fermilab Report* will no longer include a listing of Fermilab publications.

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Dates

January 7, 1991
Deadline for receipt of materials for February Physics Advisory Committee Meeting

February 1-3, 1991
Physics Advisory Committee Meeting

March 19, 1991
Deadline for receipt of material for April Physics Advisory Committee Meeting

April 19-20, 1991
Physics Advisory Committee Meeting

May 6-9, 1991
Particle Accelerator Conference, Sheraton Palace Hotel, San Francisco, California. For further information contact Rene Donaldson, SLAC, 415-926-2585 or BITNET [RENED@SLACVM].

May 22, 1991
Deadline for receipt of the material for June Physics Advisory Committee Meeting

June 22-28, 1991
Physics Advisory Committee Meeting