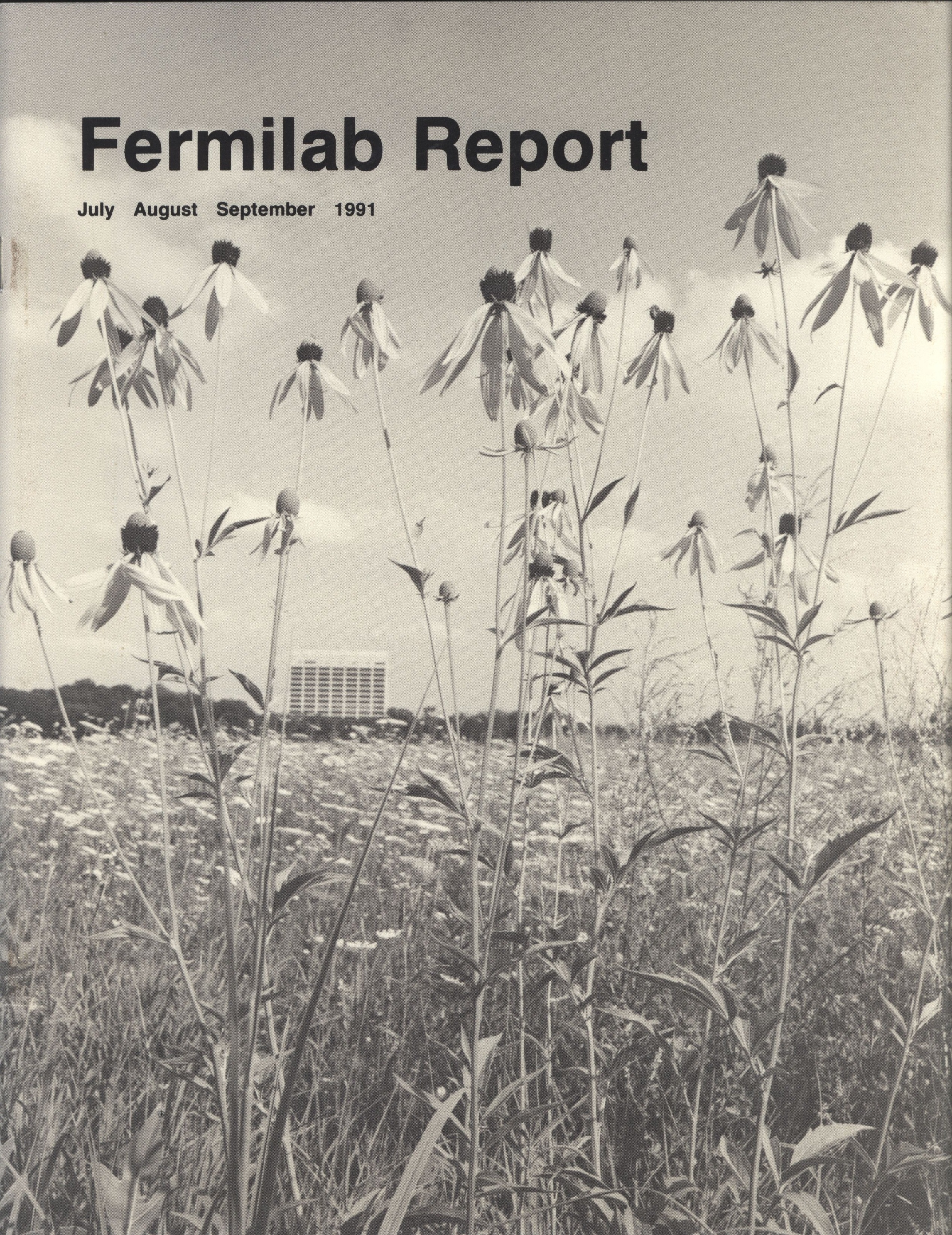
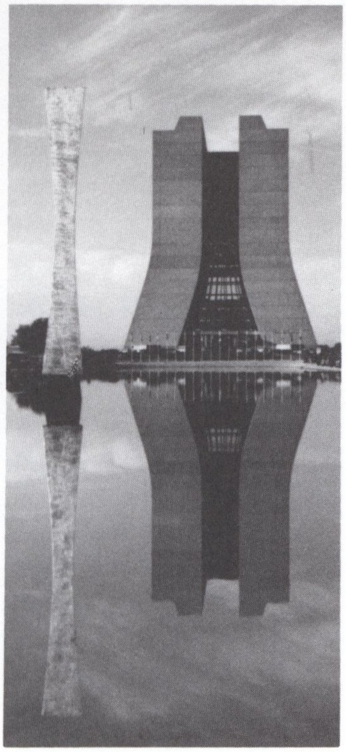
Fermilab Report

July August September 1991





Fermilab

Fermi National Accelerator Laboratory, popularly known as Fermilab, is one of the world's foremost laboratories dedicated to research in high energy physics. The Laboratory is operated by Universities Research Association, Inc. under a contract with the U. S. Department of Energy.

Since its founding in 1967, Fermilab's mission has remained unchanged: to understand the fundamental particles of matter and the forces acting between them. The principal scientific tool at Fermilab is the Tevatron—the world's first superconducting accelerator and currently the highest energy collider in the world. Protons and antiprotons travel at nearly the speed of light in the Tevatron's tunnel which is four miles in circumference.

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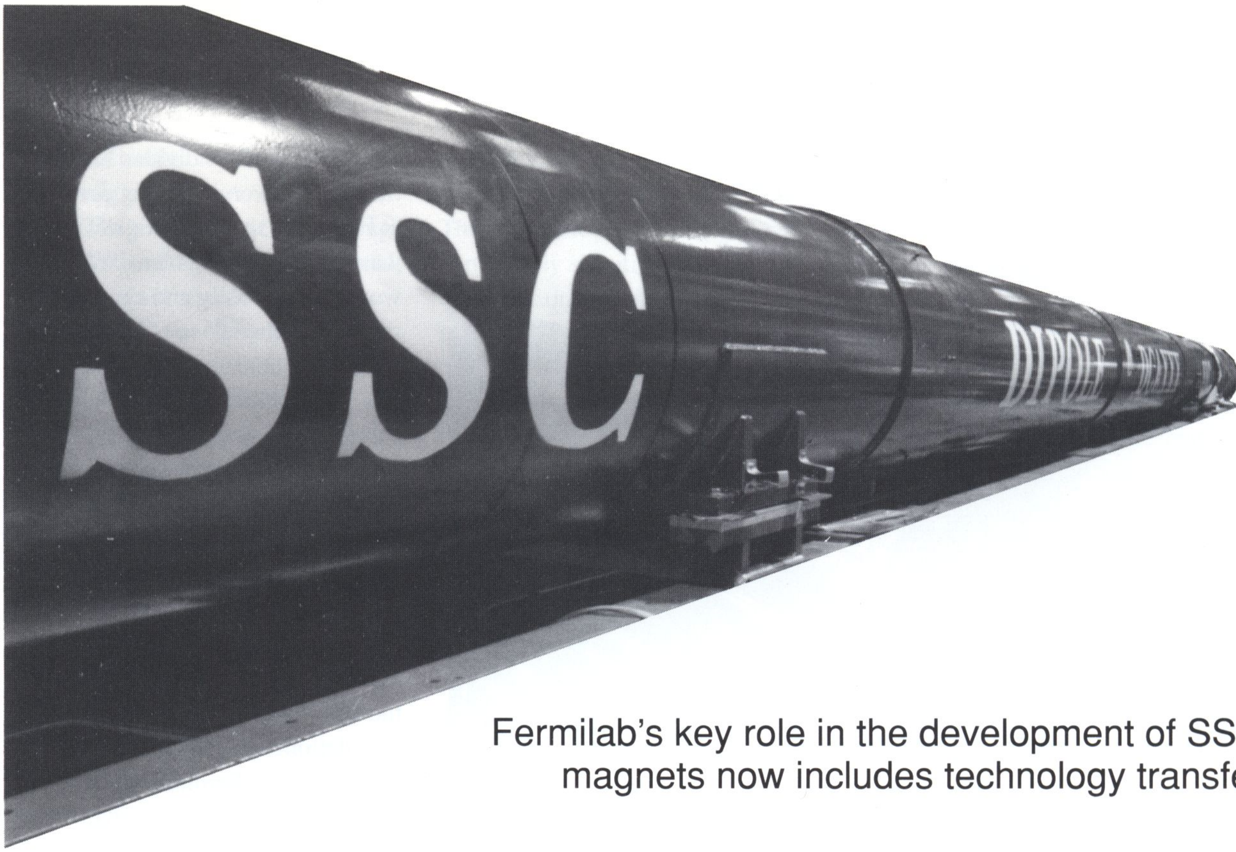


Fermilab's key role in the development of SSC magnets now includes technology transfer

SSC dipole magnet update

by Kate Metropolis

Carl Lewis could sprint by one in about a second and a half. To a 20-TeV proton, they appear less than a millimeter long. But the 15-meter dipoles that will guide protons around the SSC have required tens of thousands of hours of hard work and nimble thinking. The eyes of Congress are now focussed on the demonstration of a half-cell—five dipoles and a quadrupole—of industrially produced magnets, scheduled for November 1992. This "string test" must succeed for Congress to authorize the SSC Laboratory to begin digging a tunnel to house the accelerator.

Magnet experts at Fermilab, however, are concentrating less on the string test than on the design of the magnets and the production process. The test conditions will not reveal much that is new about the magnets themselves.

"The string test is essentially a systems test," says Jim Strait, who has led the magnet design work at Fermilab. "It will give the accelerator people the opportunity to test the cryogenic system, and the controls for ramping a string of magnets, and the quench protection systems in a way that can't be done in a single magnet test."

Fermilab, Brookhaven and Lawrence Berkeley Laboratory (LBL) have been part of a collaboration on SSC magnets from the early days of the project. In December 1989, the SSC Laboratory announced a major change in the magnet design: the aperture would be increased from 40 mm to 50 mm. Since then, without any significant departure from the schedule, Fermilab has contributed detailed designs and procedures, a technology transfer program to industry is well under way, three pleasing short magnets have been built and test results from the first long magnet will soon be in hand.

Rodger Coombes, deputy director of the SSC Laboratory's magnet division, gives Fermilab high praise. "Fermilab has been very cooperative, and things there have gone very smoothly. We're very happy."

One more centimeter

According to Strait, "Tracking studies done at the SSC showed that, given realistic construction errors, the dynamic aperture of the 40 mm

Winding coils are (l to r) Leslie Peters (SSC), Don Inverstine (General Dynamics) and Douglas Zdunich (Fermilab).

magnet was so small that they would have difficulty storing the beam during the twenty minutes of injection, where you're sitting at low field and need the biggest aperture. A twenty-five percent increase in the aperture would solve that problem." The magnet collaboration has taken advantage of the opportunity to use what had been learned from the 40 mm magnets in working out the new design.

"We scaled the width of the cable with the aperture, thereby putting in 50 percent more superconductor than we had before," Strait explains. "This caused the price of the magnet to go up, but also gave us a greater field margin between the operating current and the short sample limit of the conductor. Based on conductor that just meets the critical current specification, previously the margin was about four percent. It is now up to nine or ten percent. For reference, the Tevatron runs within three percent of the quench current of its weakest magnet."

Two designs

A task force comprising experts from Brookhaven, Fermilab, LBL, and the SSC Laboratory recommended pursuing variations on the basic design: one at Brookhaven and one at Fermilab. Fermilab's design was chosen as the baseline design; the Brookhaven design was the back-up.

"The magnetic design and the fundamental mechanical design are the same," says Strait. "There are some differences: the iron yoke that provides magnetic return paths for the flux is joined vertically in our design, and we use a different method of clamping the coil ends. The magnets are designed to be one hundred percent interchangeable. But, assuming that our magnets work properly, it will be our magnets that go in the string test."

The two labs divided some of the work: the cryostat was designed at Fermilab; the magnetic design was done at Brookhaven. "We've worked very easily and cooperatively with them," says Strait.

LBL produced the new larger cable. "That turned out just fine," says Paul Mantsch, head of Fermilab's Technical Support Section. "The group at LBL are very, very good at cabling."

In March of last year, after agreeing on the scope of work with the SSC Laboratory, and performing calculations for the detailed design and assembly, Fermilab started building the first magnets with the new aperture. The first to be finished were model magnets, identical to the full-length dipoles in all important respects, except that they are only a tenth as long. That means that they can be built faster and can more easily be extensively tested, providing assembly experience and early performance data.

Early success with short magnets

The first model magnet, completed in December 1990 and tested in the first week of January 1991 (meeting the schedule that had been drawn up nine months before), worked "exceedingly well" according to Strait. "The design operating current is 6600 amps. It had one training quench at above 7000 amps and then went to its short sample limit at about 7500 amps."

The short sample limit is reached when the cable carries the maximum possible current for a given temperature and magnetic field. In a training quench, a small section of cable or wire moves into a new, snugger position when current flows. The process generates enough heat to cause the cable to go normal, but the magnet's performance is ultimately improved by the increased mechanical stability of the strands of superconductor.

"To my mind," Strait continues, " equally impressive, if not more impressive, is that the field quality was very good. The harmonics were almost within spec."

Two more model magnets have been completed and tested. They exhibited essentially no training, going to the short sample limit at about 7500 amps. None displayed significant training after a thermal cycle to room temperature.

"The good quench performance, which results from good mechanical performance, shows that we learned a lot from the 40 mm magnets and knew fairly well how to put the new magnets together," says Strait. "I think a lot of the good performance results from that work." But magnet behavior is still sufficiently mysterious to keep even the most expert builders from arrogance. "We also have to attribute some luck, because there's enough that's not understood about how these magnets work."

The field quality also benefited from the 40 mm magnet work. "In particular," says Strait, "we took account of all the mechanical and thermal deflections that the components would undergo during assembly and cooldown and excitation, so the conductors would end up where the magnetic designers wanted them when we got all done. The sextupole moment, which is particularly sensitive to small construction errors, has been measured to be somewhere between plus one and plus three units for the magnets so far. The SSC spec says that the systematic sextupole has to be less than plus or minus 0.8 unit and the rms about the systematic value has to be less than 1.15 units. All magnets must be within three sigma of the mean. With these first magnets we're at a point now that took us several years to achieve with the 40 mm magnets.

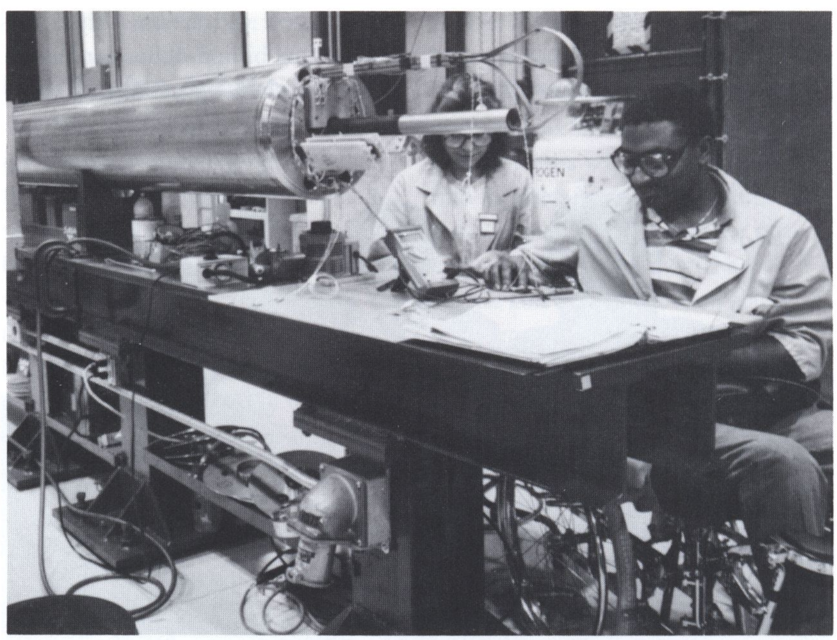
"We're as close, or closer, than we ever expected to be at this stage. You expect to have to tweak, but the tweaking that's required in these magnets is small."

Long magnets to be tested soon

Before producing long 50 mm magnets, the Lab wanted to finish assembling two long 40 mm magnets. "The more we learned about the 40 mm magnets," says Mantsch, "the further ahead we would be." Although those magnets performed well from a quench standpoint, the harmonics were poorly controlled.

"The most important thing we learned from them," says Strait, "was how not to build magnets. We had a tremendous number of assembly problems, and we did our utmost to learn from our mistakes."

After the major work required to adapt the three 17-meter-long



Working on a cold mass internal interconnect assembly are Eloisa Ruiz (Fermilab) and Marlon Jackson (General Dynamics).

presses that are used in the production of each magnet to the new 50 mm design, production began. After practicing the assembly procedures using low quality cable, winding of the first long 50 mm coil began in May. That magnet is scheduled to reach one of the two test stands, which have been converted to match the new geometry of the magnets, by November, and within a few weeks researchers will be poring over the quench test results. Twelve more magnets are in various stages of production.

Strait is pleased. "The long 50 mm magnets are now going together quite smoothly."

According to Gale Pewitt, who manages the SSC magnet program at Fermilab, the SSC Laboratory's support was essential. "With stimulation, cooperation and funding from the SSC, we did a number of things to enhance the schedule and the probability that the magnets would work." In addition to assisting with assembly area improvements, the SSC Laboratory supported procurement procedures such as incentive plans for vendors and ordering components from more than one source when the ability of one vendor to deliver was in doubt. The SSC Laboratory also agreed to send some thirty-five technicians, engineers, quality assurance experts, and procurement specialists to supplement Fermilab's resources. "They have been an outstanding addition," Pewitt says.

Technology transfer

To help ensure that industrially produced magnets will succeed, twenty-six employees of General Dynamics, the company selected as the leader in the dipole magnet competition, have been immersed in Fermilab's magnet program since late spring. (Westinghouse, which will compete with General Dynamics for the final billion-dollar contract to produce eight thousand dipoles, has had employees in residence at Brookhaven since August. Two Westinghouse people are also full-time observers at Fermilab, although they will not participate in the hands-on work.)

After attending classroom lectures, observing assembly on the floor, and finally joining the Fermilab crew on assembly, the General Dynamics people are responsible for assembling seven of the thirteen long magnets to be made at Fermilab. These seven will be candidates for the string test.

Mike Packer, who will be manager of plant operations in the factory General Dynamics is building in Hammond, Louisiana, calls the experience of coming to Fermilab fabulous. "The physicists, the engineers, and the technicians have been extremely open, sharing, and encouraging. A lot of friendships have sprung up. It's surpassed our expectations."

Mike Blessing (General Dynamics), Bob Williams (SSC), Gale Pewitt (Fermilab) and John Carson (Fermilab) combine their talents for a successful Laboratory/Industry collaboration.

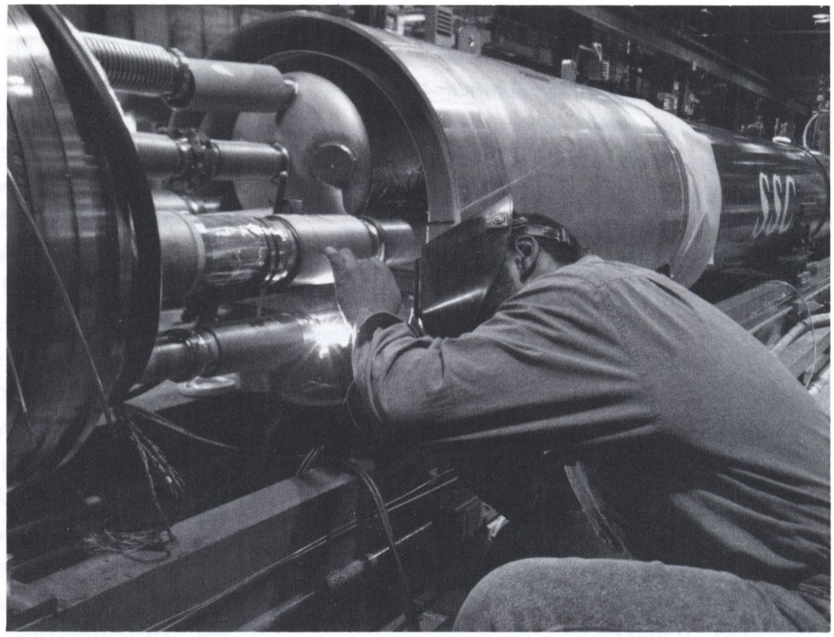
Packer says that the company was looking beyond the SSC when the decision to bid on the SSC magnets was made. He points to the demand for mass-produced superconducting magnets that magnetic energy storage batteries for public utilities, magnetically levitated trains, and x-ray lithography devices create. Although General Dynamics has supplied national laboratories and industry with a number of superconducting magnets, the orders have been for one or two at a time.

Indeed, before coming to Fermilab none of the General Dynamics employees here had ever built a magnet. The company's philosophy was that an aptitude for teamwork was more important than directly related experience. The twenty-one new hires from Louisiana, who will hold the lead positions once the Hammond plant starts up, were chosen from a hundred times as many applicants after a rigorous selection process that included a full day's assessment of their ability to learn from and to teach others.

The approach gets high marks. "This collaboration has gone infinitely more smoothly than I ever imagined would be possible," says Jim Strait. "They've sent high-quality people here." Gale Pewitt remembers a previous job where he worked with a group of Navy submarine crew members. "I noticed what a different personality they had. You could hit them, but you couldn't shake them up. A lot of people can't stand change, they can't stand criticism, they can't stand a lot of stuff, but if you've got to live in tight quarters, you've got to get along. Well, these people from General Dynamics could make it on a submarine. They're really top-drawer, and they mix well with our crew."

Strait also credits the Fermilab staff. "I think we have a fantastic team of physicists, engineers, and technicians at Fermilab. The success of this program is a result of the hard work and high-quality work of all of these people."

Pewitt, too, is impressed with the performance of Fermilab's people. One illustration he gives is that the production crew has been cleaning tooling for the General Dynamics assembly crew—hardly the most glamorous job on the floor. "But John Carson, the production manager, has helped everyone understand that cleaning tooling is just as important as any other job. If we don't have clean tooling, it can shoot this whole project down."



A welder completes the construction of a magnet test stand.

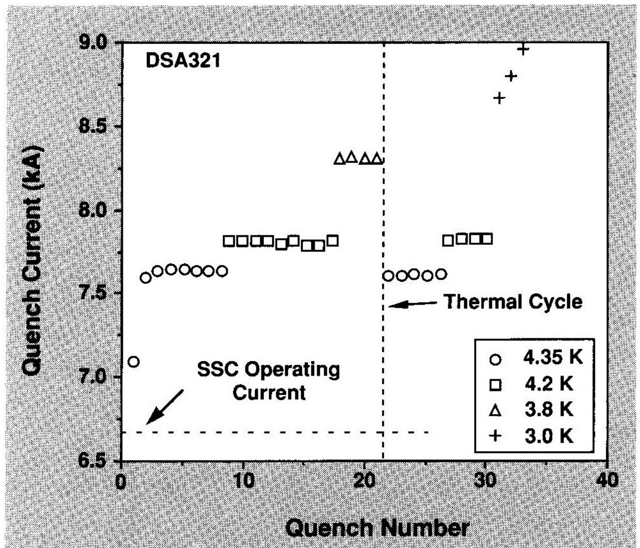
Production issues

Carson has also been addressing the other production issues that face anyone trying to mass produce several thousand magnets: Can they build magnets to adequate precision without highly skilled help? Will the tooling be affordable? Can they build them quickly enough and cost-effectively enough to stay within the budget and time constraints of the project?

"What's really critical in this business is that everything be as reproducible as possible—that is, from one magnet to the next they look alike—and that you minimize failures," Carson says. Echoing Strait's reflections on the value of the 40 mm program, he continues, "We're happy with all aspects of the tooling now. For the 40 mm magnets, we had unfortunately underdesigned the collaring press beams. That was a mistake on our part, and it caused a lot of problems because of overstressed insulation. We've stiffened the press beams, now, and so far there haven't been any problems with shorts in the 50 mm magnets." Molding fixtures for the new magnets improve the precision with which the coils are placed and thus the quench stability of the magnets.

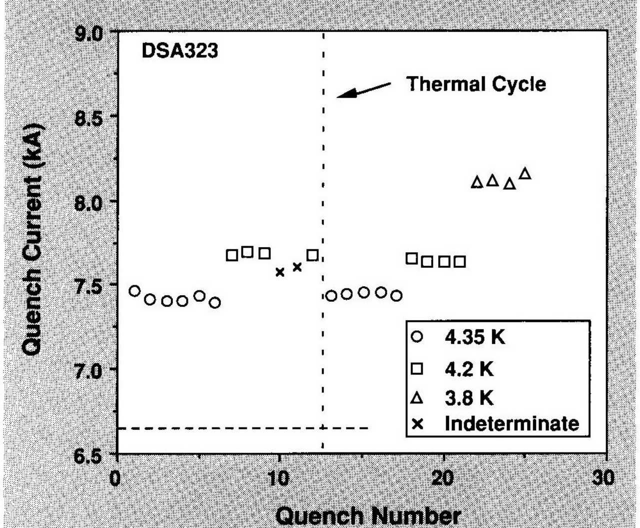
Welding equipment has also been improved with the addition of television monitors. These enable the operator to follow the four welds down the 15-meter length of the magnet without having to peer through the tooling. All adjustments can be made from the control console.

Design refinements, too, have been made with an eye toward increasing reliability of production.



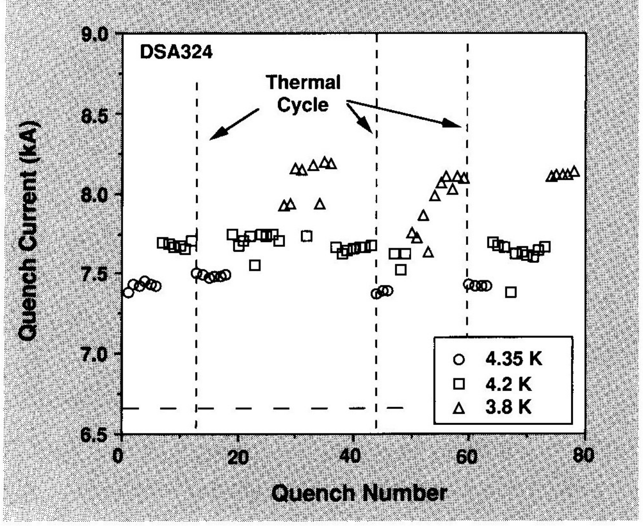
Quench Plot DSA321

The first 50 mm aperture collider dipole model magnet, DSA321, exhibited excellent quench behavior. It experienced only one training quench significantly below its plateau current at the nominal operating temperature of the SSC (4.35 K), and this was still well above the SSC operating current of 6.6 kA. Quench currents were determined by ramping the magnet at 16 A/s until it spontaneously went normal. Quench plateaus were obtained at 4.35 K, 4.2 K and 3.8 K to verify that the magnet was at its conductor limit. During the second thermal cycle (a thermal cycle consists of bringing the magnet from room to operating temperature and then back to room temperature), the magnet was cooled to approximately 3.0 K. The three quenches obtained at this temperature were at fields approaching 9 T. That the magnet behaved well at these fields is evidence of the structural integrity of the mechanical design.



Quench Plot DSA323

The second 50 mm aperture model magnet, DSA323, went immediately to its conductor limit at 4.35 K. As is typical of these magnets, there was no retraining between thermal cycles.



Quench Plot DSA324

Model magnet DSA324 performed well through 4 thermal cycles. An axial end force is provided for the coils via set screws threaded through a thick stainless steel end plate which is welded to the magnet shell. This force was removed during the third thermal cycle to determine whether it is necessary for good performance of the magnet. It is believed that this resulted in the observed training, especially at 3.8 K, during this cycle. When the end force was reestablished for the fourth cycle, training was not observed.

Fermilab has improved the geometry in the end regions of the coil to minimize stress on the conductor, thereby reducing the possibility of scuffing that could lead to shorts. The iron yoke has been rotated ninety degrees, so the split is now along the vertical axis to help quench stability and improve magnetic field quality.

Magnet assembly has become a highly disciplined activity. A document several inches thick, known as a traveler, describes virtually every step along the way, and accompanies each magnet during fabrication. The people making the magnet sign off in the traveler virtually every time a procedure has been completed, and the SSC quality control inspectors monitoring magnet fabrication also sign off on the most crucial tasks. Don Tinsley is responsible for overall quality assurance for the magnet project and has been instrumental in adapting the travelers to the 50 mm magnets.

As every good cook knows, it's impossible to make a good meal with poor ingredients. Pewitt credits the procurement specialists at Fermilab who have joined Gregg Kobliska's Technical Support team in this crucial aspect of the work.

From room temperature to 4 K in 15 centimeters

The cryostat has two conflicting functions: to keep the superconducting coils at 4.35 K, and to support the magnet's weight. A premium is placed on taking the least possible space, since the larger the cryostat the more difficult it will be to install the magnets. Tom Nicol and his team have designed a cryostat in which a mere fifteen centimeters come between the top of the 4 K chamber and the 300 K outside world.

Although the weight of the magnet increased from fifteen thousand to twenty-five thousand pounds with the increase in aperture, this has been accommodated with only a thirteen percent gain in the heat leak. (The heat leak to the 4 K region in the Tevatron magnets is 1.6 watts per meter; in the SSC magnets, 0.023 watts per meter: a factor of seventy improvement in performance.)

Fermilab's low-heat-leak support post design for the SSC has already been successfully adapted for the RHIC and LHC dipoles, as well as for Fermilab's own new low-beta quadrupoles (see *Fermilab Report*, November-December 1990).

Multilayer insulation is an important part of the cryostat, and Fermilab researchers have been exploring its effectiveness between the 20K and 80K thermal radiation shields of the cryostat. Thermal conductance in this range is governed by different phenomena than those that dominate in the 300K to 80K range. The results of this research will be applicable not only to accelerators but to superconducting energy storage batteries, aerospace projects and cryogenic liquefaction processes.

Testing

Everyone is eager for the testing to begin. A dramatic increase in the amount of diagnostic instrumentation on the 40 mm test magnets led to striking improvements in the ability to understand and correct deficiencies. These improvements happily appear to have been transferable to the short 50 mm magnets. The question is whether it is also transferable to the long magnets.

"Even though the cross section of the long magnets is the same as the short magnets, " says Peter Mazur, who heads the magnet testing work at Fermilab, "you have tremendous thermal contraction along the length of the magnets. That may occur differently for different components, so the structure of the ends is going to be different in a short magnet and a long magnet."

Musing on the upcoming testing, for which SSC Laboratory test plans concentrate on quench performance, Mazur continues, "We don't know if this will be a step backwards that we'll have to work our way up from, or a great leap forwards. People have various theoretical ideas, but we have to be experimenters."

But confidence seasons his detachment. He points out that SSC magnets have already achieved the performance required for a collider with nineteen TeV per beam. "Even if we find that there are important problems to be solved, that doesn't mean that they cannot be solved. I think they can—in a very straightforward way." ■

Fermilab computing moves to UNIX

by Roy Thatcher

Introduction

At Fermilab we are in the middle of a major computer revolution. In only two years we have come from a state in which a negligible fraction of the Laboratory's computing was done under the UNIX operating system to where a definite majority of all computing cycles here are performed on UNIX platforms. This article deals with this transition from mainframes and minicomputers running traditional operating systems—all very different from each other—to workstations running UNIX, an operating system that runs on scores of different machines and looks fundamentally the same on all of them. Here we discuss the reasons for this jump, what we gain from it and the price we pay to gain these advantages. We shall also discuss the implications of buying UNIX workstations from several different vendors.

Why Fermilab (and the world) is moving to UNIX

In a real sense the revolution we are seeing is a product of our market economy. The competition in new RISC technology has been truly intense. The speed of the processors has grown enormously while costs dropped rapidly. At any given time the fastest chip on the market had only a few months to reign before being dethroned by a newcomer that was not only faster but, in most cases, cheaper as well. The time of the chip development cycle has been shrinking steadily until it is a small fraction of the time required to develop a special operating system for a particular chip. As a result, a hot new workstation would be fatally late to market if it had to wait for such an operating system. UNIX is the answer to this problem. It has been designed to be machine independent and requires a relatively modest amount of tailoring to put up on a new chip. Basically, to get UNIX up requires getting a C compiler up and tailoring the interrupt handlers and drivers to the new hardware. The process of getting a C compiler up can be shortened by buying the source code for the machine independent parts of the compiler. As an aside, note that C is not only the first language installed on any UNIX machine, but that it is subjected to a really strenuous test in the process of compiling the up-to-five-million lines of code that constitute UNIX. Other programming languages are normally not nearly so severely tested.

To summarize, the move to UNIX is forced by economics, the "bang per buck" as it is often put. The price/performance ratios for UNIX workstations has been astonishingly low for some time and they are still dropping. One can now buy UNIX workstations for which the cost/MIP is close to 1/1000 that of our last mainframe acquisition! The current prices seem astonishingly low and future price/performance ratios should be even better. This is extremely important because otherwise the cost of physics-associated computing at Fermilab would be prohibitive because we are experiencing an explosion of data. Each new generation of experiments has had much higher data rates than its predecessors even with major improvements in event selection techniques (triggers). If the dramatic growth of the data-taking in the last round seemed like a nova, the current one seems more like a supernova with some experiments estimating a total data collection of around 10 terabytes. Without the RISC/UNIX revolution Fermilab would be hopelessly swamped with data.

The strengths of UNIX

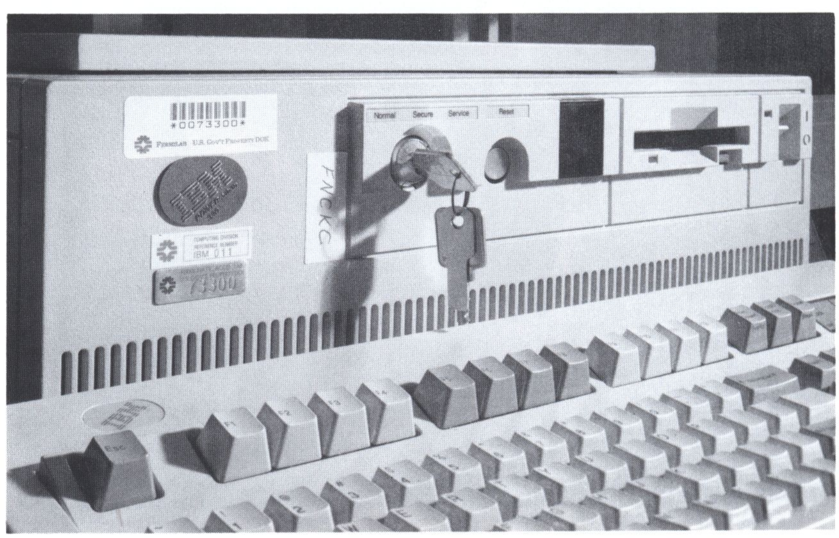
So far the only characteristics of UNIX we have examined are its ease of porting to a new chip. Let us now look at its inherent strengths and, in a later section, at its weaknesses. Among other strengths, it has truly great programming tools and the ability to combine these into much more complex tools using I/O redirection and "piping" the output from one tool into another. It is often possible to combine the UNIX utilities in a few minutes to do very complicated data manipulations that would require a programming effort of hours under any of the other operating systems we use here. We have seen programmers with years of experience in VMS and only a few months experience in UNIX shipping files from a VAX to a UNIX platform to take advantage of the UNIX "tool kit." If we compare the file systems of UNIX with those of VMS or VM, we see that UNIX supports subdirectories with an arbitrary number of levels whereas VMS supports only 7 levels of subdirectories and VM does not have them at all. The syntax for specifying files is much simpler in UNIX than in VMS. One need not specify a device, file type or version number. (The absence of versions, however, should be counted as a deficit.)

The weaknesses of UNIX

Let us address the deficiencies and problems with UNIX. The most significant ones are: it does not deal well with tapes; it does not supply the controls for regulating how users share resources; it does not support batch jobs; it does not yet support true clusters on which all the disks belong to all the machines; and disk backup is cumbersome for groups of machines.

Tapes -Tapes are a disaster under UNIX if you want to use them for anything but backup. There is no provision for tape allocation or for handling ANSI labelled tapes. Both these deficiencies have been remedied by a code written for the Computing Division. Using these new routines one can write tapes on any of the various UNIX platforms with confidence that they can be correctly read on any of the other UNIX platforms.

There are further complications that arise because we choose to use the 8mm tapes. The 8mm drives are much cheaper and the 8mm cassettes hold much more data per unit volume. An experimenter can carry in a shirt pocket an 8mm cassette that contains more data than ten

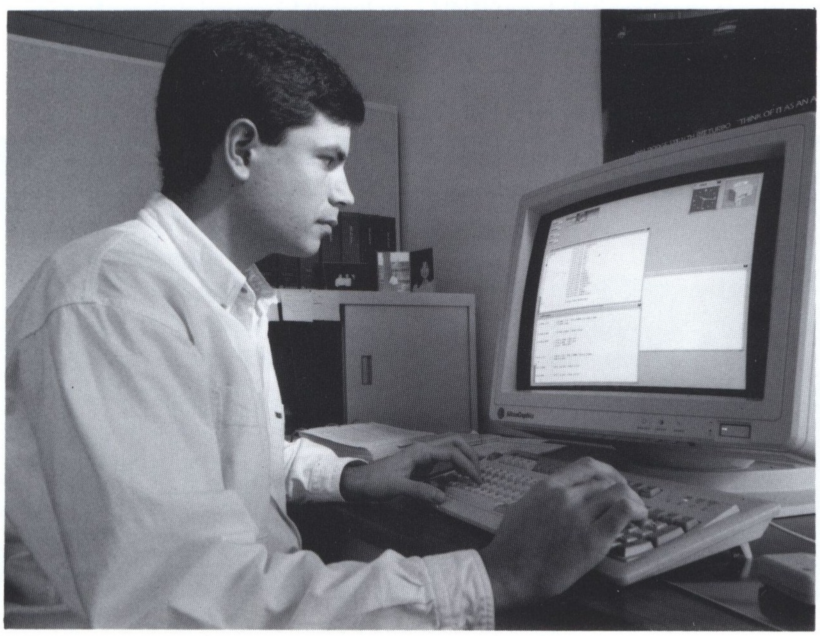


IBM-RS6000-UNIX Workstation. In this small package we have the computing power of 30 MIPS (which is the equivalent of 30 Vax 11/780s).

2400 foot reels of 9-track tape. However, we are paying the price of being at the forefront of new technology. There are a number of problems to be worked out and these are complicated by the fact that different vendors handle 8mm tape drives slightly differently. It is only in this sense that the 8mm tapes should be thought of as constituting a problem in the transition to UNIX. We should note that we are solving the problems as time goes on but at the present time some difficulties remain.

Resource sharing- UNIX provides almost no tools to allocate resources among users. The absence of a tape allocation command discussed above is a glaring example. The various versions of UNIX running at Fermilab do not all support disk quotas to prevent a program (or user) running amok from filling the available disk completely. The only control currently available on all our platforms is to group users on partitions so that each user can only fill one of the partitions. However, AT&T's newest version of UNIX, System V Release 4 (SVR4), does support disk quotas so we can expect relief in this area once all the vendors we deal with have an SVR4 version of their operating system. Furthermore, at present, there are no commercially available job schedulers that can control the allocation of CPU resources among users. However, several such schedulers are expected to be marketed soon.

Batch - A respectable batch system has provisions for queues of different priorities and keeping one user or even a group of users from hogging all the CPU time or all the tape drives. UNIX has none of these. The closest thing to submitting a batch job is to run a process in background mode. There are ways to defer the start of a process but this does little to control the allocation of batch CPU cycles among users. Commercial batch systems are being marketed and we are tracking them closely.



Matt Fausey, Central Computing Department, Farms Development Group, develops software such as Cooperative Processes Software (CPS) Batch.

Clusters- True clustering means all computers in a cluster own all disks in the cluster jointly. UNIX lacks this but does have the ability through NFS to allow a user on one computer to access a disk on some other computer (over the network) as if the disk were on the user's computer. In this sense all machines can share all disks but there are performance issues.

Backup - Backing up the disks of a group of UNIX machines is cumbersome using only the tools that normally come with UNIX. The notion of a "cluster" of machines is foreign to UNIX so each disk belongs only to one of the machines.

Peculiarities of UNIX

UNIX takes a bit longer to learn than VMS but less time than VM/CMS. Compared to operating systems such as these it is full of quirks. No command abbreviation is allowed but the commands are extremely terse. Many of the command names are whimsical and convey no hint of their function.

For example, "awk" takes its name from the initials of the authors of that command, and "biff" is named for the dog belonging to the author of that command. Many different people have contributed to UNIX and no one has played policeman to make sure that all contributions conform to some standard. As a result, there are inconsistencies in syntax from command to command but these are minor and constitute little impediment to a new user. Also, error messages are often cryptic or nonexistent.

One often finds that a certain strength of UNIX is closely related to one of its weaknesses. Two characteristics that often surprise the new user are that UNIX views all devices as files and all files as just a stream of bytes. But the portability of UNIX hinges to an important degree on the simple (almost simplistic) way it looks at files and devices.

David Potter, Central Computing Department, Farms Development Group, keeps production going on the IBM farm.

The multivendor environment at Fermilab

The biggest single advantage of buying the Lab's UNIX "boxes" from a variety of vendors is, again, economics. Vendors are forced to compete and we can buy at better prices. We are undoubtably money ahead but we face the drawback that UNIX varies somewhat from vendor to vendor. As a result, the Lab as a whole and the Computing Division in particular have more problems to solve. One faces what Tom Nash, Head of the Fermilab Computing Division, calls "matrices of incompatibility." The FORTRAN compilers from the various vendors of UNIX work-stations differ not only from VAX FORTRAN but from each other. The access to 8mm tape differs from vendor to vendor.

Systems administration tools vary considerably from one vendor to another. Even the location of certain standard system files varies from platform to platform. Graphics support is more complicated in the many-vendor world. Even which terminal keys perform such functions as deleting the last character or interrupting a running program can vary from vendor to vendor. User support is more difficult, time consuming and costly than if we had chosen to buy only from one vendor.

The difficulty to be tackled is how to minimize the problems to the users and to those supporting users which are caused by the variations from one platform to another. The answer is to standardize as much as possible. One face of this is to provide standard utilities for systems administration chores such as backup and adding new users. Another is to standardize the user environment as much as possible so that a user can move between Silicon Graphics, IBM, SUN, DEC (ULTRIX) and whatever else we may buy and have things look the same. The key bindings, default terminal types, special utilities, software products should all work the same on all machines. To establish that uniformity, the FERMI UNIX ENVIRONMENT was created. Because the vast majority of new UNIX users here are already experienced VAX users, the environment established is closer in things like key bindings to VAX/VMS than to one of the more traditional UNIX choices. We have a site-wide licence for EDT+, which is a close clone to DEC's EDT editor. "Products" such as HBOOK or GEANT are accessible via a "setup" command as on the FNAL VAX cluster. Where necessary we are writing utilities or working with a vendor to remedy certain problems.

Helping the individual user move to UNIX

Setting up the Fermi UNIX environment was certainly an important step in the task. In addition, the Computing Division has produced a document called *UNIX at Fermilab* (Document GU0001 in the Computing Division Library). This report is a concise guide to those features of UNIX that are most useful to someone trying to use UNIX here in the Fermi environment includ-ing some important locally-written utilities such as the ones for command line editing and printing on laser printers over a network. It ignores topics such as the Bourne shell and the standard UNIX editor, vi, which are, so far, not very popular here.

Furthermore, the Computing Division regularly offers a special one day introductory course called, *Introduction to UNIX for Program Development at Fermilab.* It focuses on giving the new user a fundamental understanding of how UNIX really works, what the common pitfalls are and how to avoid them and how to go about importing code from across a network and converting it to run under UNIX. Another course has been offered that goes into more of the details of program development and debugging under UNIX.

UNIX for more than data reduction

So far, we have discussed UNIX at Fermilab as if it were only for dealing with physics data. However, one of the the earliest uses of UNIX work-stations here was for graphics ap-plications such as Computer Aided Design (CAD). Any task that is compute-intensive as opposed to I/O intensive is a good choice to move to a UNIX workstation. The Accelerator Theory Group and the Theoretical Astrophysics Group have already done so.

UNIX in the extended high energy community

Fermilab has been a trail-breaker in the use of the new generation of high-powered UNIX/RISC workstations in high energy physics. TheFermilab talks given at the *Computing in High Energy Physics Conference*, at KEK, Tsukuba, Japan last March stirred up strong interest in the rest of the high energy physics community. This contributed to the formation of a new user group, HEPIX, specifically for users of UNIX in this field. Fermilab hosted the first meeting of HEPIX on September 23-25 of this year

Conclusion

UNIX is here for the foreseeable future. That is a fact whether you love it, hate it or have strongly mixed feeling as do so many users. UNIX will dominate the CPU intensive computing at Fermilab until some new, highly-portable, easily-installed operating system takes its place as the choice of manufacturers of super-fast workstations. Existing workstations allow staggering computing power to sit on a desk top and the future ones will be much faster. Tremendous power in a cheap package has forced us to go to a different, much more distributed model of how intensive computing is done. Support for users is more difficult, but in the end, this move makes possible the analysis of the physics—which is the very reason that Fermilab exists. ■

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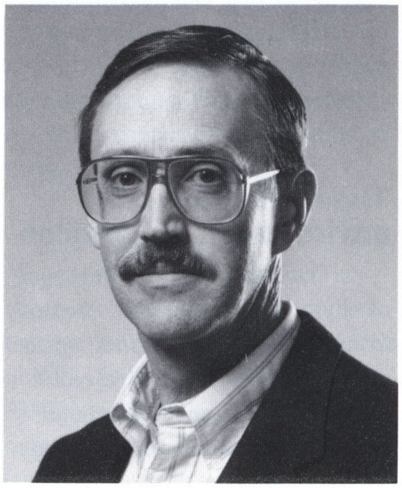


Roy Thatcher is Coordinator of Training for the Computing Division and a member of the UNIX task force formed to make the transition to UNIX as painless as possible. He regularly teaches a one day course in UNIX and consults on many aspects of computing. In an earlier incarnation he did operations research for Container Corporation of America and Amoco.

The ParkNet environmental research program at Fermilab

by Rod Walton

In July of 1989, Fermilab was dedicated as the nation's sixth National Environmental Research Park. What does that mean for Fermilab, for environmental researchers and for science in general? How is the Fermilab Research Park utilized? Who is participating in the research? What specific problems are to be addressed by this DOE research program? I will try to answer these questions in this article.

NEPA sets course

The network of National Environmental Research Parks grew out of the implied mandate of the National Environmental Policy Act (NEPA) of 1969 for all federal installations to "identify environmental amenities and values and give them appropriate consideration in their decisional equations."[1] Since the first Research Park was designated at Savannah River Laboratory in 1972, other parks have been established at Los Alamos National Laboratory, Pacific Northwest Laboratory, Hanford, Idaho National Engineering Laboratory, Oak Ridge National Laboratory, Nevada Test Site and of course here at Fermilab.

The system that these parks comprise is known as ParkNet. The mission of the ParkNet program is to quantitatively monitor the environmental impact of human activities, develop methods that can be used to predict environmental responses to human activites, demonstrate the impact of various activities on the environment and evaluate methods to minimize adverse impacts. The amount and kinds of environmental research being carried out at these research parks includes massive, well-funded Environmental Research programs like those at Savannah River and Oak Ridge Laboratories, and more modest efforts like those at the Idaho laboratory and the emerging program at Fermilab. The range of research topics is truly impressive, including population and ecosystem biology, physiological ecology, radiation biology, energy and nutrient dynamics, consequences of environmental stresses of different kinds and atmospheric science. The Fermilab program is guided by the ParkNet Program Description, which was signed by Fermilab Director John Peoples on July 1, 1991.[2]

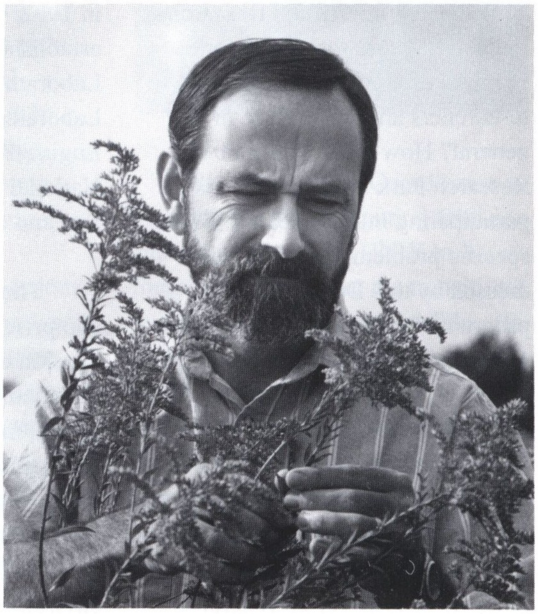
Through the ParkNet network, research carried out at each of the Research Parks can be synthesized in order to address environmental questions on a continental scale over the long term. Many of the Research Parks have maintained data on climate, atmospheric variables, air and water quality and ecological communities for several decades. ParkNet researchers have an ideal framework for working with such existing data, and integrating new data into the search for solutions to big questions of environmental science and ecology. The mechanism for doing this is the "computational workshop." Several times per year, researchers focus on datasets generated by the research parks and at other locations[3], and analyze the data toward the end of attacking a major problem. For instance, recently at a workshop sponsored by the Idaho National Engineering Laboratory, datasets from research parks and other sites were examined to learn more about patterns of statistical variability in climatic parameters and community composition over about twenty years and a wide geographical area. The outcome of this workshop was the preparation of two manuscripts for publication in scientific journals. Studies, like this one, on the fundamental properties of large-scale ecological systems are vitally important to the understanding of how those systems might react to the increasing load of stresses that human activities place on them, and also of how past environmental insults might be remedied or future ones avoided or mitigated. While this aspect of ParkNet is still very new, it is anticipated that in the future, problems of continental scale, such as climate change, regional air quality changes, water resource allocation, and ecosystem stress due to environmental pollutants will be profitably addressed through the computational workshop method.

Although the amount of data available for Fermilab is sparse, we have contributed datasets to several efforts in the past, and have participated in data manipulation and analysis. In the future, Fermilab's involvement in computational workshops will increase. The ParkNet Office has recently installed a powerful new computing system designed to communicate with other ParkNet parks, and to process very large datasets. We plan to host a computational workshop here in 1992.

Fermilab offers unique opportunities

Fermilab offers some unique opportunities for pursuing environmental research. The most visible of these is the nearly 800 acres of reconstructed prairie and native grassland available on the site. Beginning in 1992, we will be establishing nearly 300 acres of prairie/grassland experimental areas for future experimental manipulations. These areas will be rigorously controlled to provide an excellent outdoor laboratory for future research. In addition to the prairies and grasslands, Fermilab's landscape is rich and complex, having many areas of wetlands, aquatic sites, old-fields and forests. The fabric of this landscape allows researchers to sample several ecosystems simultaneously, and affords the opportunity to examine directly the processes that govern interactions between two or more ecosystems at their interface.

At Fermilab, unlike most of the other sites, there is no resident Environmental Research Division. Therefore, research must be done either by contract, or by researchers from other institutions who bring their own funding to the Fermilab Research Park. Fermilab offers a unique opportunity for environmental scientists and ecologists to perform field experiments. The Laboratory grounds are relatively protected from vandalization, and at the same time, Fermilab is accessible for researchers and technicians. Many areas of the Lab are available for research of this kind, and currently there are several projects underway.



Rod Walton examines a goldenrod plant as part of his research on the evolution of plant defenses against insects.

- Dr. Art Weis, from the University of California at Irvine, has investigated the population genetics and evolution of trophic relationships between gall insects and their plant hosts using plants and animals at Fermilab. His current research, part of which will also be carried out at Fermilab's Research Park, will investigate the evolution of plant defenses to insect attacks.

- Dr. R. Michael Miller and Ms. Julie Jastrow of Argonne National Laboratory have conducted a series of studies in the reconstructed prairie areas, investigating changes in soil structure, chemistry and associated mycorrhizal fungi associated with the gradual succession of agricultural systems to native grasslands. Their work has resulted in several publications and seminar presentations.

- Dr. Steven Juliano and a group of graduate students from Illinois State University are investigating community structure and the population dynamics of several species of treehole dwelling mosquitoes. The researchers are supported by a grant from the National Science Foundation, and have produced several papers and presentations from this work.

- Ms. Mary Hennen, an ornithologist from the Chicago Academy of Science, is conducting a study on the breeding biology of the Eastern Bluebird in northern Illinois. She has placed a number of bluebird boxes around the Laboratory site as part of that study.

It is the goal of the ParkNet program at Fermilab that the ecological and environmental research carried out here be as high-quality as that of the physics. The emphasis for the Fermilab ParkNet Office in selecting and sponsoring these studies is on obtaining well-developed proposals that demonstrate researchers' ability to investigate important ecological questions in a rigorous scientific fashion. To assist in selecting the best proposals, and to provide ongoing guidance in the administration of the research park, a six member Environmental Advisory Committee meets annually and communicates regularly to discuss the direction of the program. This committee is composed of highly respected ecologists from across the nation, representing a wide variety of expertise.

The ParkNet program affords scientists working at DOE facilities, including Fermilab, an opportunity to make important contributions to the understanding and solution of environmental problems at a time when such problems are being discovered at an alarming rate, and interest in the scientific community and the general public is at an all-time high. ■

References

[1] DOE ParkNet Notebook (Draft), Ch. 2, "The Research Parks' History" (1989).

[2] Copies of this document are available from the ParkNet Office, 708-840- 2565.

[3] Part of the program involves promoting active collaboration with scientists at universities and other institutions. One of the most fruitful of these collaborations has been with scientists from the Long Term Ecological Research (LTER) program administered by the National Science Foundation.

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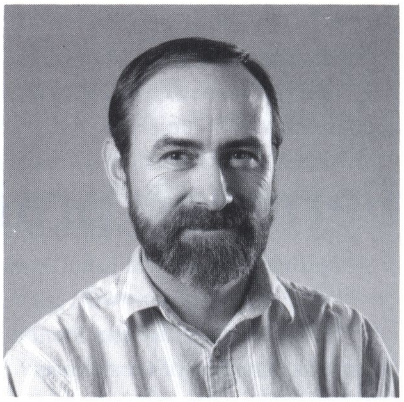


Rod Walton is head of the Parknet Environmental Research Program at Fermilab. He received his PhD. in biology from Indiana University in 1986. His research interests have spanned a broad range of topics in Population Biology, Behavioral Ecology and Evolutionary Biology. He has published the results of his work on raccoons, salamanders, birds and insects. Currently, Rod is collaborating with researchers from Yale University on models of diet choice in a South American raptor (the Snail Kite) and pursuing research at Fermilab on the evolution of plant defenses against herbivorous insects with a collaborator from the University of California at Irvine. He also maintains an active interest in conservation issues and environmental ethics.

Fermilab prairie: The next generation

by Brian Dick

Consider for a moment the cinematic portrayal of the the pre-settlement prairie in the recent Academy award-winning movie *Dances with Wolves*. Near the three-quarter mark, a band of plains-wise Native American Indians stalks the encroaching Union Army troops on the wide open Dakota prairie. Despite being denizens of this grassy habitat, they move with some difficulty as they try covertly to follow the army wagon train to rescue their soldier-turned-Indian hero. The Indians, it seems, can't hide from the bluecoat convoy in the shin-high patches of neatly trimmed prairie grass.

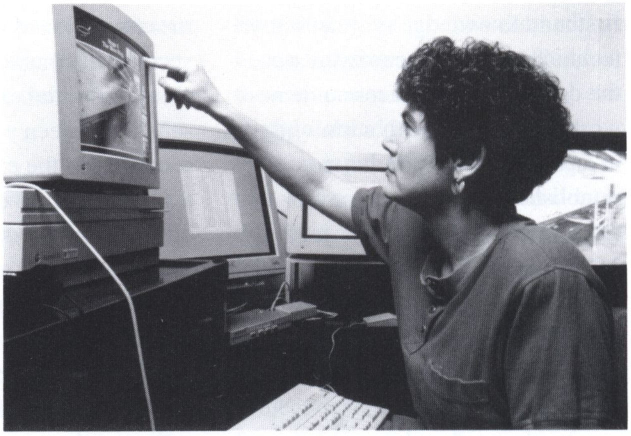
But is this low-cut rendering of the grasslands a factual discrepancy, or is it really a true portrait of the American prairie of the 1800s? Perhaps in portions of the shortgrass Dakota plains, but not by a long shot in the tallgrass prairie of the Midwest, ecologists and prairie experts say. Back then, vast expanses of tallgrass prairie covered most of the Midwest, and anything short of a combine would have had a hard time cutting through the twelve-foot high blades, stalks and leaves that could very easily have concealed a horse and rider. Farming, urban development and a burgeoning population have virtually brought an end to the prairie glory that was the Midwest, and today's children often suffer the misconception that a "prairie" and a weedy vacant lot are one and the same. At Fermilab though, a small but impressive remnant of the prairie of yesteryear lives on in the almost 800-acre prairie reconstruction project — a good portion of it inside the Tevatron's four-mile circumference ring. Using a small parcel of the available prairie resource, a Fermilab collaboration is now developing an education program that hopes to dispel any myths and aid prairie reconstruction by educating today's students on prairie ecology.

If this latest educational innovation were a movie, it would be a sequel: *Particles and Prairies.* The director would be Elizabeth Quigg of Fermilab's Computing Division. Although not the fantasy stuff of movies, *Particles and Prairies* is a radically innovative new middle school program bringing together two of Fermilab's remarkable resources partly through the medium of interactive video. Under Quigg's leadership, ecology and education have "merged files" to form an inventive type of computer learning station in which the classroom proper no longer exists. Blurring the line between the traditional *classroom-experience-coupled-with-infrequent-field-trips* is only one of the essential components to be found in the various interactive videos Quigg is creating. Sitting amidst a bevy of computer and television screens in her cubicle on Wilson Hall's eighth floor, she has an unobstructed view into the Education Office across the atrium where in the summer months students and teachers from around the country come to participate in an ongoing cavalcade of educational programs and workshops. The programs themselves are forward thinking, allowing students and teachers alike to experience science with aggressive hands-on techniques and interrogative formats. Their primary aim since the creation of the first program, *Saturday Morning Physics*, in 1979 has been to make science more interesting, more challenging, and perhaps most importantly, more enjoyable for everyone involved.

It was there in 1990, in the progressive learning environment of the Education office, that the possibility for an interactive teaching aid to be used in the soon-to-be-completed Fermilab Science Education Center was realized. Friends of Fermilab, the Education Office's progenitor, developed a plan to utilize the nearby Fermilab prairie in its proposed P*articles and Prairies* program, hoping to open the Fermilab National Environmental Research Park to junior and middle school classes. The unique program would allow students to be scientists by conducting research that would supplement the data of professional ecologists. As a basis for their proposal to the Illinois State Board of Education's Scientific Literacy Program, Friends of Fermilab cited a need identified by area educators to provide experiences for students outside the traditional classroom setting. "At the same time, we recognize the need to revitalize the skills of current science teachers and to maintain interest in the teaching of science as a career," Friends of Fermilab proposed. Field research was to play one part in the program, extension into the students' communities another, and pre- and post-teaching activities for the classroom a third part. To meet a portion of these objectives, someone needed to design a multimedia learning station that would enhance the traditional laboratory experience by allowing young visitors to survey the prairie from the vantage point of a high-powered personal computer. A grant from the Illinois State Board of Education allowed Quigg to begin work.

A prototype interactive video focusing on particle accelerators received critical acclaim from participants in this summer's education programs, members of the Education Office staff, and DOE, industry, and media representatives who visited Fermilab in late June. Drawing direction from the feedback, Quigg then began the task of creating a similar set of interactive videos for the *Particle and Prairies* program.

Unlike a one-dimensional textbook-oriented course, students will use the natural resources of the Fermilab prairie to generate information on its ecosystem that may aid the ongoing efforts of researchers working on prairie reconstruction. Under supervsion, program participants will plant and maintain a diversity of prairie plants while controlling the growth of weeds in restored prairies. Kathleen Greenawalt, a teacher associated with the *Particles and Prairies* program, explains: "The difference is that we want to link students with scientists. Fermilab will have something for everyone —*Beauty and Charm* for the physical sciences; *Down to Earth* for earth sciences and soon *Particles and Priaries* for the life sciences." Other activities in the nearby prairie will expose students to sampling, counting and recording plant populations in quadrats, while data



Liz Quigg is currently creating interactive, multimedia learning stations for the new Science Education Center scheduled for completion early next year.

analysis in the related science lab will allow students to project trends that will be incorporated in the Fermilab prairie management program.

From the point of view of a professional ecologist, unleashing students with little or no experience in the biological sciences into the prairie could prove to be a valuable asset along the way of data collection and select field research activities. According to Dr. Rod Walton, head of the Parknet Environmental Research Program at Fermilab, these students, and their teachers as well, might generate new insights into prairie development from the perspective of the non-scientist. "They'll bring a completely new point of view to the work," Walton theorizes. "It's possible that (students and teachers) could give us new ways of looking at things." For example, if a scientific group involved in an authorized study was interested in monitoring the long-term ph levels in the Fermilab lakes, non-scientists could, with some supervision, perform that activity and aid the professional researchers while simultaneously gaining firsthand knowledge of quantitative techniques. Walton can even see the day when student researchers work one-on-one with a biologist in a program very similar to established student/mentor programs akin to the Summer Institute in Science and Technology in which experience shares equal billing with theory. But for now though, the *Particles and Prairies* program must learn how to walk.

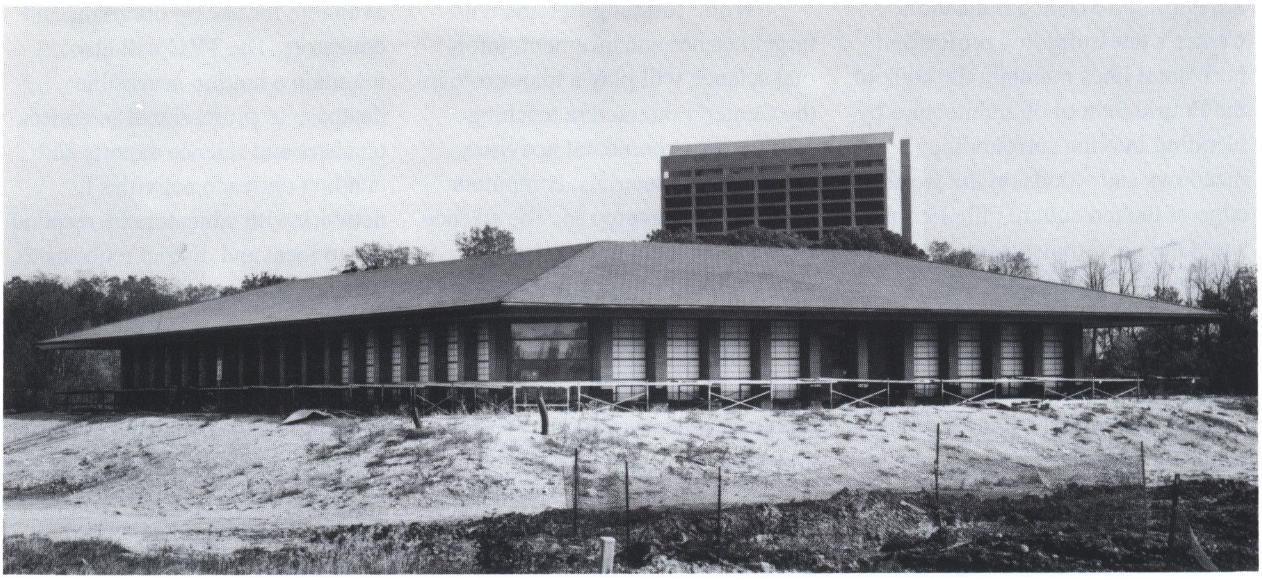
The first interactive video designed to accompany field research activities is part of a comprehensive station on the biotic and abiotic aspects of the prairie habitat. *Bird Call Concentration*, patterned after the board game of the same name in which players try to match corresponding cards, is a specimen identification program in which a grid appears on the computer screen, prompting the student to physically touch a square and turn over a card. Instead of seeing the face of a card, the student hears a distinctive bird call. The student then tries to match the bird call with one from another square. When a match is made, the computer flashes the name and a color picture of the bird whose call the student matched. "The person doesn't sit back passively," Quigg says. "Touch is the most intuitive way to work with a computer."

Sound effects reproduced on compact disc as well as digitized voice recordings engage the aural sense while limitless tiers of graphic images provide ever-changing windows of exploration for the eyes. The Cornell Laboratory of Ornithology's Library of Natural Sounds provided calls of the swamp sparrow, the brown-headed cowbird, the meadowlark and other indigenous species on compact disc to complement the visual experience. A touch sensitive screen adds the final sensation to the experience, enabling a student-user to communicate without any keyboard computer interface. Paramount to all other features though, the learning stations' user-friendly screens will allow rapid access to other topics, subtopics and a help button at the flick of a finger.

The progression in an interactive teaching station, in contrast to that in a book or videotape, should allow for limitless tangents of learning, experimentation, and sensory response, Quigg explains. Likewise, her three remaining interactive video stations will maintain the same random access format, she adds. Those currently in the planning stage include a component examining the history of the surrounding area's geology, pre-settlement days, and agricultural development; another discussing the significance of Fermilab as an outdoor laboratory; and another detailing the prairie restoration, from its seasonally changing appearance to the management techniques of controlled burning, seed collection and planting. The principle objective to consider when building highly intelligent teaching aids is for the stations to be instructive, not confusing, according to Quigg. "If something might arouse curiosity, you want to have a link."

Like the growth of the Fermilab prairie, some evolution in the interactive videos over time is expected. Actually, Quigg reveals a certain amount of change is always welcome. Prairie ecologists involved in the Fermilab reconstruction from its beginning would no doubt agree.

"It's good to watch other people use the programs," she says as she puts *Bird Call Concentration* through its paces in an office demonstration. "That way I can make adjustments to see what works better." ■



Science Education Center nears an early completion

by Brian Dick

Colliding beam physics isn't the only program at Fermilab looking forward to 1992. While physicists are already preparing for the startup of the collider run during next year's early months, planners in Fermilab's Education Office are scanning the western horizon, anticipating construction of the new Science Education Center to be completed at the same time.

Informal plans for the Center have been in the making since the mid-1980s when the first generation of institutes, workshops, research appointments and classes for students evolved out of the growing need to supplement science and mathematics programs routinely taught at the elementary and high school levels. As word in the news media spread that an alarmingly smaller number of students were choosing to pursue career paths in science and mathematics-related fields, curriculum development at Fermilab kicked into high gear with the creation of more and farther-reaching education programs aimed at interesting younger students in science and keeping them involved with science through the higher grades.

Outside looking in

The need for a centralized facility in which to develop and instruct education programs was clearly understood at Fermilab where courses such as the phenomenally popular *Saturday Morning Physics* had been operating at peak capacity since their inception. In keeping with U. S. Department of Energy (DOE) education objectives, the design and construction of the new building earned approval, and in October of 1989 Secretary of Energy Admiral James D. Watkins and Congressman Dennis Hastert broke ground on the future spot of the Fermilab Science Education Center. Construction began in February of 1991. Today the Center nears completion slightly ahead of schedule, undergoing the finishing touches that will soon allow it to house more than forty Fermilab precollege education programs.

Designed by Fermilab Director Emeritus Robert R. Wilson (with project design coordination coming from Ed Crumpley, formerly of Construction Engineering Services) the Fermilab Science Education Center's one-story low profile and horizontal lines maintain the style of the Prairie School of architecture by blending into the surrounding meadows and woods on the western edge of the ten-square mile Fermilab site. Glass and translucent panels between brick piers form the exterior walls, and the Center sits atop a six-foot earthen berm that distinguishes it from the surrounding level terrain. A nearby cedar path winds through the thick grove of trees and over two creeks to join the Center to Wilson Hall, Fermilab's central Laboratory building.

Even with her eighth floor Wilson Hall office facing the Center, Education Office Program Manager Marjorie Bardeen periodically has a 'seasonal' difficulty keeping an eye on the construction. In the summer months, the dense leaves of the nearby forest occlude her view, but in the fall after the trees have dropped their leaves, the view improves. "They're putting the roof shingles on today," she notes with enthusiasm one day in late August, shortly after the start of the school year. "(The Center) is going to give us an opportunity to expand with programs for younger students and their teachers because it gives us a facility made just for them."

A full house

From the outside, the Science Education Center's austere features cloak a number of interesting design accomplishments. Inside, a science laboratory will hold 60 students and the computer classroom 36, with enough room left over for a hands-on physics area, Teacher Resource Center (TRC) and offices.

While formal programs will target teacher enhancement, informal science will play a major role in the Center's interactive teaching stations, environmental activities, audio-visual materials, computers and science playground. The science lab's interactive learning stations will offer hands-on math and science activities across the school curriculum, while the interactive teaching stations, *Quarks to Quasars*, will represent aspects of science and mathematics unique to Fermilab research in the areas of accelerators, detectors, scattering experiments, the structure of matter, and the structure of the Universe. The underlying basis for creating such a liberally-structured learning environment stems from the philosophy that students derive a real understanding of science through creative investigation and thoughtful questioning.

Teachers will find resources to make their classroom a more challenging and rewarding place in the TRC where materials will be available for use by librarians and educators. The TRC will also maintain a hotline-accessible database of professional scientists, teachers and science experts and conduct outreach activities to network with educators by responding to local and district requests to enhance science education.

Once complete, the Center will hold in store some unique opportunities for students to do field research, combining this distinguishing facet with innovative classroom-centered coursework.

The objective is clear: "Our goals are to increase science literacy for all students and to encourage more students—particularly those from underrepresented groups—to pursue careers in science, technology, engineering, and mathematics," Bardeen explains. "With over twenty-six laboratories involved in DOE programs, we're working together as members of a team to do an outstanding job and have a national impact." ■

Launched in 1989, the Science Education Center will soon be a reality. (L to R) Congressman Dennis Hastert (R-IL), Hilary Rauch, DOE, Secretary Watkins and Fermilab Director John Peoples.

Lab notes

Fermilab wins R&D 100 award

Fermilab has been named one of the winners of the prestigious 1991 R&D 100 award for the High-Amperage Solid State Switch (HASSS). Developed by electrical engineer Age Visser, HASSS can continuously carry direct currents as high as 10,000 amperes and switch them off in less than 150 microseconds.

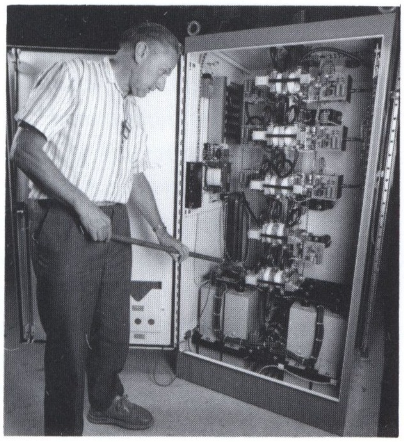
In this competition, the publishers of *R&D Magazine* recognize the achievement of significant new technology. One hundred winning products are selected annually on the basis of their importance, uniqueness and usefulness from a technical standpoint. This year U.S. Department of Energy laboratories won over one-third of the awards.

Secretary of Energy James D. Watkins said, "I am delighted to learn that the Department of Energy laboratories this year won 36 R&D 100 awards. I congratulate Fermilab researchers. Obviously they have taken to heart one of their laboratory's most important missions, technology transfer, and are making innovative technology available for the benefit of the country."

The extensive superconducting magnet development at Fermilab demonstrated a need for a device such as the HASSS to switch the energy stored in a superconducting magnet to an external resistor when a fault is detected. The HASSS accomplishes this switching task in a reliable, elegant and cost-efficient manner.

Unlike conventional circuit breakers which have a limited lifetime and need to be reconditioned after several operations, the HASSS has no mechanical parts and can be used over and over again. Prior to the development of the HASSS, no current-limiting devices were available in ratings as high as 10,000 amperes, 1000 volts dc.

The HASSS can be used in any application where high-current, high-voltage, high-speed dc switching is required. Particularly relevant is the burgeoning field of superconducting magnet technology which already forms the heart of the medical diagnostic technique known as magnetic resonance imaging and is the basis for future transportation possibilities.



Age Visser develops award winning strategy.

In addition, with appropriate design modifications, the HASSS could be utilized as a high-speed ac switch that would limit large fault currents to preselected levels in high-power alternating distribution systems. Thus the HASSS could protect future ac and dc installations against damage and destruction costing millions of dollars.

The black-tie awards banquet honoring the recipients was held September 19 at the Museum of Science and Industry. Accepting the award on behalf of Fermilab was Associate Director Dennis Theriot. In attendance were Age Visser, developer; Walter Jaskierney, Electronics/Electrical Department technician who assisted Visser on the development of the HASSS; Robert Trendler, Associate Head of the Research Division; Paul Czarapata, Electronics/Electrical Department Head; Richard Carrigan, Jr., Head of the Office of Research and Technology Applications and John Venard, Fermilab Licensing Officer.

The 1991 award marks the thirteenth time in the last twelve years that Fermilab has received a coveted R&D 100 Award. The Laboratory received its first round of awards in 1980. The Negative Hydrogen Ion Source, developed by Charles W. Schmidt, won a prize that year, as did the Energy Saver Dipole, developed under the leadership of Richard Lundy and former Fermilab Director Robert R. Wilson.

Peter McIntyre's Electron Cooling System won in 1981. The system cooled antiprotons at an energy (200 MeV) suitable for antiproton accumulation. No design before this one had achieved more than 80 MeV.

Nineteen hundred and eighty-three was a banner year for Fermilab. The Laboratory claimed four R&D 100 awards that year. Frank F. Cilyo developed the Precision Electric Current Sensor, which, according to *R&D Magazine*, "provided an isolated voltage signal, zero to ten V, which was proportional to the direct current (unidirectional) being measured." The Sensor was useful for closed-loop control applications.

Ed Barsotti's "ECL Camac" Ultra-High Speed Computer, according to DOE, applied to "high-energy physics which require ultra-fast real-time filtering and preprocessing of data to identify interesting, rare events amongst the many occurring during collisions."

C.H. Rode's Tevatron Liquid Helium Transfer Line also won in 1983. The Tevatron was lauded for its simple design and highly reliable transfer line, as well as its comparatively low cost. The Slip-Ring Stepping Motor, developed by Hans Kautzky, rounded out the 1983 awards. The motor was used in Fermilab's fifteen-foot bubble chamber.

Ronald J. Walker's Spectrographic Nitrogen Detector won an R&D 100 Award in 1984. The sensitive, relatively inexpensive device, called "stable and easy to maintain and operate" by the DOE, helps protect against nitrogen contamination in large helium liquefier operations.

The Magnetic Wire Position Transducer, developed by Hans Jostlein and a research team, won a 1985 award. The transducer, the magazine said, "aligns and monitors the alignment of machinery and other objects." It is equal to laser systems in stability, linearity and precision, but hardier and much less expensive.

The Video Data Acquisition System, developed by Alan E. Baumbaugh, Kelly Knickerbocker and a research group, was described by *R&D Magazine* as a "high-speed triggerable image data acquisition and analysis system for high-energy physics, astronomy and other fields using images or image data." It won a 1986 award.

The ACP Multiprocessor system won a second award for Fermilab in 1986. DOE notes that Tom Nash and his colleagues developed the multiprocessor "to meet the huge and increasing data processing needs of particle physics research which could not be obtained, economically, in the commercial market."

In 1989, a group headed by Tom Nash and Estia Eichten developed the ACP Multi Array Processor, which took an award. The system allows a group of computers to work together on a single problem, and yields a great deal more power than a super minicomputer system of the same price. ■

Fermilab and IBM dedicate powerful new computing facility

Fermilab and IBM dedicated a powerful new computing facility that sets new standards for cost-effective high-performance computing. The system consists of a "farm" of sixty-eight IBM RISC SYSTEM/6000 workstations. The individual processors cooperate on parallel solutions of demanding computing problems. Such loosely coupled configurations of independent computers have been dubbed "farms."

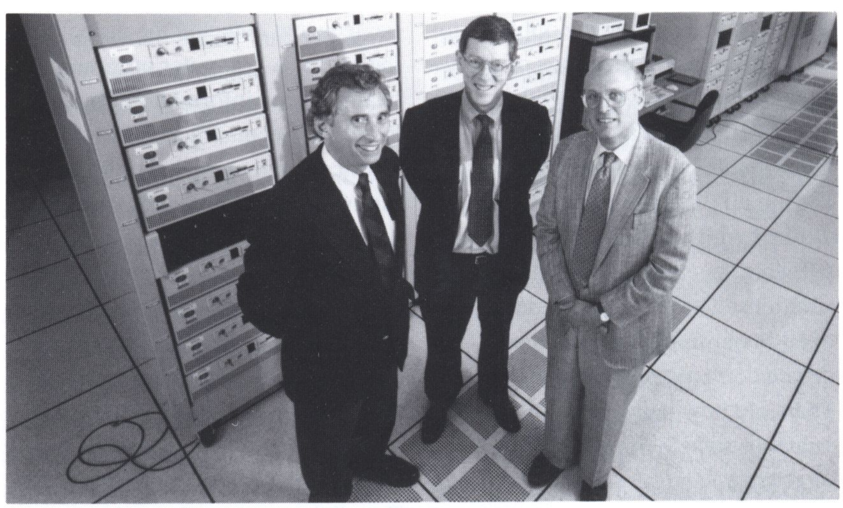
The IBM farm recently unveiled is the latest in a series of highly cost effective computing farms at Fermilab. It has the computing capacity of more than 1700 traditional mini-computers.

The new farm marks the beginning of an IBM/Fermilab research collaboration on farm computing. Commenting on this collaboration, IBM Vice President for Science & Technology, John Armstrong, said, "Since the mid-80s, Fermilab has been a pioneer of loosely coupled parallel farms of computers to meet the demanding requirements of its science. Fermilab researchers continue to push the technological envelope in this area, which has recently emerged as a key direction for high performance computing. This year, IBM entered a research collaboration with Fermilab, recognizing Fermilab's leadership in the area of farm computing, as well as the area's broad applicability for our customers. IBM welcomes the opportunity to leverage its own research efforts by joint programs with Fermilab and other Government-funded laboratories."

Recently, in testimony before the Senate Committee on Energy Research and Development, Fermilab's Director, John Peoples, stated, "Although our quest is for fundamental knowledge, and not its practical application, we must solve many practical problems to carry out our work. We need to do sophisticated experiments and perform enormously complicated theoretical calculations, and both of these activities rely on a lot of innovative thinking. Our research simply cannot go forward without the development of new technology. Work that at first glance may appear esoteric is actually vital to supporting and strengthening the country's intellectual and technological development. In fact the best way for us to pursue our goals involves links with education and industry that coincide with the best interests of the public that supports us."

A continuing challenge at Fermilab is the availability of enough computing power to process all the data produced by its many experiments. Computer farms have solved this problem by exploiting the fact that smaller computers have become much more cost effective than large ones for solving many problems. In a situation where funds are limited, but demand for computing is not, computing resources can be maximized by using large numbers of small computers.

The processors in a farm are connected over a communications network so they are able to ex-



Fermilab Director John Peoples, John Armstrong, IBM Vice President for Science and Technology and Tom Nash, Head of the Fermilab Computing Division dedicate a powerful new computing facility.

change data. This allows all the computers to share data from a single set of tape and disk drives. The sharing of these peripheral devices and the fact that a farm works collectively on a single problem at a time distinguishes farms from mere collections of workstations. Special software has been written at Fermilab to make it possible for scientists to use a farm effectively in a manner similar to that of a single large computer. Called "Cooperative Processes Software," this software runs on a variety of computer platforms, even allowing for the use of heterogeneous farms made up of different types of computers.

Tom Nash, presently the head of Fermilab's Computing Division, led the group that built the first computer farms. He recalls, "We recognized in the early 80s that our experimental computing needs could only be met if we took advantage of the cheapest computer technology. In those days that meant raw 32 bit microprocessors. Now we can use powerful RISC based workstations. The technical challenge continues to be ensuring that collections of small, cheap computers work together effectively and in a way that is manageable by our computer users. During all this time physicists have worked with computer designers and software specialists to provide solutions. These solutions, developed in our unique application-driven computer design environment, are now being recognized as valuable outside our special field of science."

Fermilab's first farms came on line in 1986. These were based on Fermilab-designed CPU modules using commercial 32-bit microprocessors (primarily the Motorola 68020) in a standard industrial bus (VME), as the Laboratory hastened to exploit this newly available computing technology. These first farms were highly successful, growing to over 500 individual computers in eight separate farms. As industry took advantage of this same technology to produce low-cost high-performance workstations, later generations of farms were designed using workstations from vendors including Digital Equipment Corporation and Silicon Graphics, Inc. The newly dedicated computer was acquired following what was one of the first formal competitive request for proposals for a farm computer system. Eight computer vendors submitted proposals.

Each of the many experiments at Fermilab collects data from millions of collisions of high energy particles. Each collision "event" is recorded as an intricate electronic description built up from the many devices that detected the particles in the event. A computer program examines the information for each event and reconstructs it into the physics parameters that define the momentum, energy, and point of origin for each of the particles produced in the collision. This information is used by physicists to analyze the experiment and compare with theoretical expectations. An immense amount of computer time is needed to reconstruct all the events produced. The Fermilab computer farms have been primarily applied to this event reconstruction application. Each event's data is assigned to one of the computers in the farm. Without the use of computer farms, the experiments would be severely limited in their ability to process data.

The new IBM RISC SYSTEM/6000 farm has been benchmarked on the typical Fermilab mix of reconstruction programs. It runs at over 1750 times the speed of a VAX 11/780. The Digital Equipment Corporation's VAX 11/780 is a minicomputer that first appeared in the early 1980s. Its performance is commonly used as a standard of approximately 1 million complex instructions per second (MIPS). By this measure, Fermilab's total installed computer farm capacity, including the new system, exceeds 4000 VAX-MIPS, and this number will grow to nearly 6000 VAX-MIPS by the end of 1991.

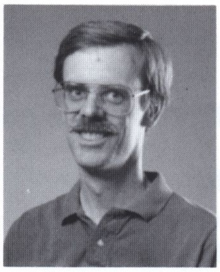
The computing facility was dedicated to the memory of Charles (Chip) Kaliher, a Fermilab computer specialist who died suddenly earlier this year. Kaliher had been a leader of Fermilab efforts to make several generations of Fermilab farms available to its computer users. The new system was named the Chip Kaliher Parallel Processing Farm. It will be known on computer networks as FNCK in his honor.

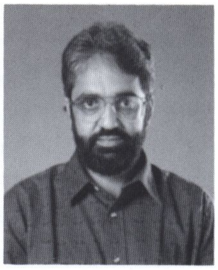
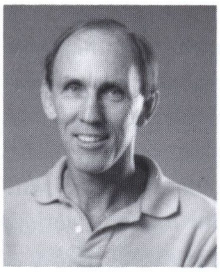
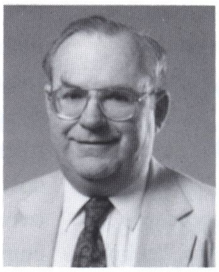
Among the speakers at the dedication were John Peoples, Director of Fermilab and John Armstrong, Vice President for Science & Technology at IBM. Chip Kaliher's family also took part in the dedication ceremony. ■

Appointments

Accelerator Division

Stephen Holmes was appointed Head of the Accelerator Division. This appointment was effective August 26, 1991 for a term to run until September 30, 1994. In his new role as Accelerator Division Head, Holmes assumes responsibility for coordinating the large number of accelerator enhancements now underway which are expected to assure the discovery of the top quark at Fermilab in this decade and to create new capabilities in the fixed target arena. Holmes will also continue to serve as Fermilab Main Injector Project Manager.




Stephen Holmes *David Finley* *Vinod Bharadwaj*
Richard Andrews *Dixon Bogart* *Regina Rameika*

He will be assisted by four Associate Division Heads.

Richard Andrews was named Associate Head for Support. The Associate Head for Support is primarily responsible for coordinating the activities of the Support Department. In his new capacity, Andrews will coordinate job assignments within the Support Departments to facilitate the activities of the Systems and Main Injector Departments. He will also serve as liaison to Facilities Engineering Services on issues related to civil construction outside of the Main Injector Project, and as liaison to the Computing Division.

David Finley was designated the Associate Accelerator Division Head for Administration, Environment, Safety, and Health (AESH). The new AESH office has been created in order to assist the Division Head with the requirements of running a technically oriented division of over 500 people in an atmosphere which provides an appropriate level of attention to issues relating to ES&H. The Associate Head for AES&H will advise the Division Head on policy regarding ES&H matters, and work with the other Associate Heads to provide consistency in division-wide implementation of the Laboratory's Environmental, Safety, and Health policies. Finley will also supervise the Division Headquarters staff.

Dixon Bogert was appointed as the Associate Accelerator Division Head for the Main Injector Project and Deputy Project Manager. The Associate Head for the Main Injector serves to support the Fermilab Main Injector Project Manager. His primary responsibility is support for planning, budgeting and scheduling and coordination of design and construction of the Fermilab Main Injector. "The Main Injector is an interesting and challenging project," said Bogert, "It is critical to the success of several important high energy physics research experiments in the later 1990s."

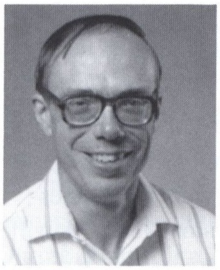
Vinod Bharadwaj was designated the Acting Associate Accelerator Head for Systems. As Head for Systems, Bharadwaj is primarily responsible for coordinating the activities of the Systems Departments. He will coordinate accelerator operations and designate run coordinators with the acquiescence of the Division Head. He will also coordinate accelerator studies, serve as liaison to the Research Division and to the Technical Support Section.

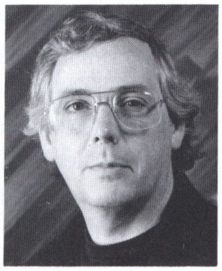
Research Division

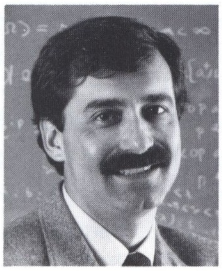
Regina Rameika was appointed Deputy Head of the Research Division. Rameika replaces Hugh Montgomery who will be working on the DØ upgrade. The Division headed by Peter Garbincius will focus its attention on bringing the fixed target run to a smooth finish. "The run has been very successful so far," said Garbincius. At the end of the current run, the Division will be preparing for the start of the collider run and insuring that research and support group staffing is properly allocated. The main focus for Rameika will be training and education in the areas of quality assurance and environment, health and safety.

Technical Support Section

Ray Hanft was appointed Acting Deputy Head of the Technical Support Section. Hanft replaces Frank Turkot who is on a one-year assignment from Fermilab to work on the ZEUS detector at DESY. As Acting Deputy Head, Hanft will be involved with budget management, ES&H activities and Tiger Team preparations. According to Paul Mantsch, Head of the Technical Support Section, Hanft will continue to be concerned with magnetic measurements at the Magnet Test Facility.







Ray Hanft
Jack Pfister

Daniel Green
Edward Kolb

Directorate appointment

Director John Peoples recently named **Jack Pfister** to the Directorate as an Assistant Director. As the newest member of the central management team, his principal focus in the coming months will be the development of new financial management systems starting with cost accounting. Pfister will also oversee the implementation of computing-related DOE orders and issues.

For the last two years, Pfister has served as Computing Division Associate Head of Technology, Tracking and Transfer. During an initial transition period, Pfister will share time between the Directorate and the Computing Division continuing his role in computer security. In this position he will further develop the computer protection plan, and insure that the Laboratory is in compliance with all public, state and federal computer laws and all DOE computer regulations.

Pfister will also give his attention to the completion of the Fermilab Computing Long Range Plan. This is a five-year budgetary and strategic planning document designed to meet both Fermilab and Department of Energy objectives.

Pfister, who has a political science degree from the University of Wisconsin, began his Fermilab career in 1980. Prior to joining the Laboratory, Pfister worked for the Department of the Army in the Management Intern Program. "This is when I entered the computing field," said Pfister. After completing his internship, Pfister joined the Department of the Navy. After ten years with the Department of the Navy working out of Washington, D.C. and London, Pfister took a position in the private sector as an account manager for SEI Consulting Firm, a business applications firm for Fortune 500 Companies.

Scientific appointments

Fermilab Director John Peoples, on the advice of the Fermilab Committee on Scientific Appointments, has announced the following appointments.

Scientist III

Daniel Green, currently Head of the Solenoid Detector Collaboration Department, earned his B.S. and Ph.D from the University of Rochester. As a postdoctoral research fellow at the State University of New York, Stony Brook, he worked on an ISR experiment on the rising of the total cross section.

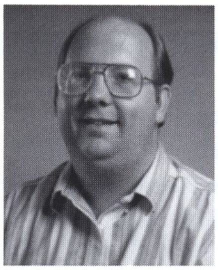
From Stony Brook, Green traveled to Carnegie Mellon University, where he was an Assistant Professor and Spokesperson of a Brookhaven National Laboratory MPS baryonium experiment. He has been a Scientist at Fermilab since 1979. At Fermilab, Green has worked on FNAL MPS Spectroscopy, E580, E623 and DØ. He became DØ Muon Group Leader in 1982. Recently, he has been involved in SSC physics and was named SDC Deputy Spokesperson.

Green was the Research Division Facilities Support Group Head from 1982-1984, Physics Department Deputy Head from 1984-1986 and Head from 1986-1990. He has served on the Fermilab Users' Executive Committee, the Organizing Committee for the DPF '90 (Rice) Meeting, and as Co-Chairman for Fermilab Breckenridge Workshop.

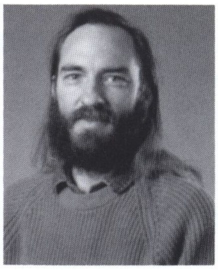
Edward Kolb is Head of the Theoretical Astrophysics Group at Fermilab and a Professor of Astronomy and Astrophysics in the Enrico Fermi Institute and the College at the University of Chicago. He earned a B.S. from the University of New Orleans, and a Ph.D in physics at the University of of Texas, Austin.

Before coming to Fermilab and the University of Chicago, Kolb was a postdoctoral research fellow at the California Institute of Technology, a J. Robert Oppenheimer Research Fellow at Los Alamos National Laboratory in New Mexico and Deputy Group Leader of the Theoretical Astrophysics Group at Los Alamos.

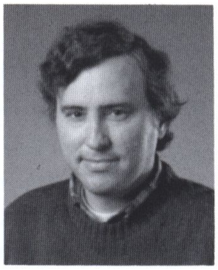
Kolb's primary area of research interest is the application of particle physics to cosmology and astrophysics. He is also concerned with science education, especially of the general public. An American Physical Society Fellow, Kolb has lectured in Europe, Australia, Japan, South Korea, and Mexico. He has served as a Visiting Professor at the University of Michigan, the University of Rome and Osservatorio di Roma and the University of Sussex.



Gerry Jackson



Peter Kasper



Ron Lipton

Scientist I

Gerry Jackson, Accelerator Division, earned his B.S. from the University of Michigan and his Ph.D. from Cornell University. While at Cornell, he served for four semesters as a teaching assistant in the Department of Physics and also as a Research Assistant at Newman Laboratory of Nuclear Studies. Jackson came to Fermilab in 1986 as a Research Associate. In 1989 he was named Associate Head of the Injector Department for Instrumentation. As a Wilson Fellow, Jackson concentrated his efforts on the construction and operation of a bunched beam stochastic cooling system in the Tevatron. Toward the end of the Fellowship, Jackson became the Deputy Spokesperson for the proposed Tevatron test of a SSC experiment called SFT, which involves the slow extraction of colliding beams via a bent crystal for fixed target B-meson research. From 1990-1991 Jackson was Head of the Instrumentation Department in the Accelerator Division. He is now dedicating his time to accelerator physics research activities and advising accelerator physics graduate students.

Peter Kasper, Research Division, received his B.S. and Ph.D. from the University of Melbourne, Australia. From 1981-1985, Kasper served as a Research Associate at the Rutherford Appleton Laboratory and was a member of the CERN neutrino experiment WA59. Later he was Chercheur Scientifique at C.E.N. Saclay and a collaborator on the Fermilab 15-foot Bubble Chamber experiment E632. In 1986, Kasper became an Associate Scientist at Fermilab. Initially he started in the Research Facilities Department of the Research Division where he was liaison physicist for all the Wide Band Photon Lab experiments and beamline physicist for the PB beamline. Just prior to the current fixed target run, Kasper became the Assistant Head of Sight Operations Department for Operations. Shortly after coming to the Laboratory, Kasper joined experiments E687 and E683. He is now the physicist-in-charge for E687 and the representative on the Fermilab Physics Council for E683. Kasper is also currently serving on the DPF '92 local organizing committee.

Ron Lipton, Research Division, has a B.S. from Indiana University and a Ph.D. from

Northwestern University. He was a Research Associate at Northwestern from 1978-1980. From 1980-90, Lipton was a faculty member at Carnegie Mellon University. He came to Fermilab in 1991 as an Associate Scientist. Lipton has spent most of his career working on Fermilab experiments. His thesis experiment, E397, measured the production of electron-muon pairs in hadronic interactions.

He participated in E515 as a postdoctoral fellow at Northwestern and as a faculty member at Carnegie Mellon. Lipton was Deputy Spokesperson for E653, a hybrid emulsion experiment studying charm and beauty production. This experiment recently reported the first observation of reconstructed hadronically produced beauty pairs. At Fermilab Lipton joined DØ, participating in the end calorimeter construction and test beam projects. Currently he is coordinating Fermilab work on the silicon tracker being designed for the DØ upgrade. ■

Dates to remember

- January 7, 1992
  Deadline for receipt of material to be considered at the February PAC meeting

- February 7-9, 1992
  Physics Advisory Committee Meeting

- March 10, 1992
  Deadline for receipt of material to be considered at the April PAC meeting

- April 10-12, 1992
  Physics Advisory Committee Meeting

- May 19, 1992
  Deadline for receipt of material to be considered at the June PAC meeting

- June 20-26, 1992
  Physics Advisory Committee Meeting

- May 26-June 4, 1992
  Summer School on Quantitative QCD Phenomenology, organized by the CTEQ Collaboration (Coordinated Theoretical/Experimental Project on Quantitative QCD Phenomenology and Tests of the Standard Model); Wu-Ki Tung, IIT/Fermilab, Chair; Jorge Morfin, Fermilab, Coordinator; Contact: C. M. Sazama, Fermilab, P. O. Box 500, Batavia, IL 60510, Telefax: 708-840-3867, E-mail: SAZAMA@FNAL

- July 13-17, 1992
  1992 Gordon Research Conference, "Particle Physics in the 90's," Proctor Academy, Andover, New Hampshire; John Elias, Fermilab, Chair; Contact: C. M. Sazama, Fermilab, P. O. Box 500, Batavia, IL 60510, Telefax: 708-840-3867, E-mail: SAZAMA@FNAL

- Nov 10-14, 1992
  Particles & Fields 92: 17th Meeting of the Division of Particles and Fields of the APS (DPF92), Fermilab, Batavia Illinois; Rajendran Raja/John Yoh, Fermilab, Co-Chairs; Contact: C. M. Sazama, Fermilab, P. O. Box 500, Batavia, IL 60510, Telefax: 708-840-3867, E-mail: SAZAMA@FNAL

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