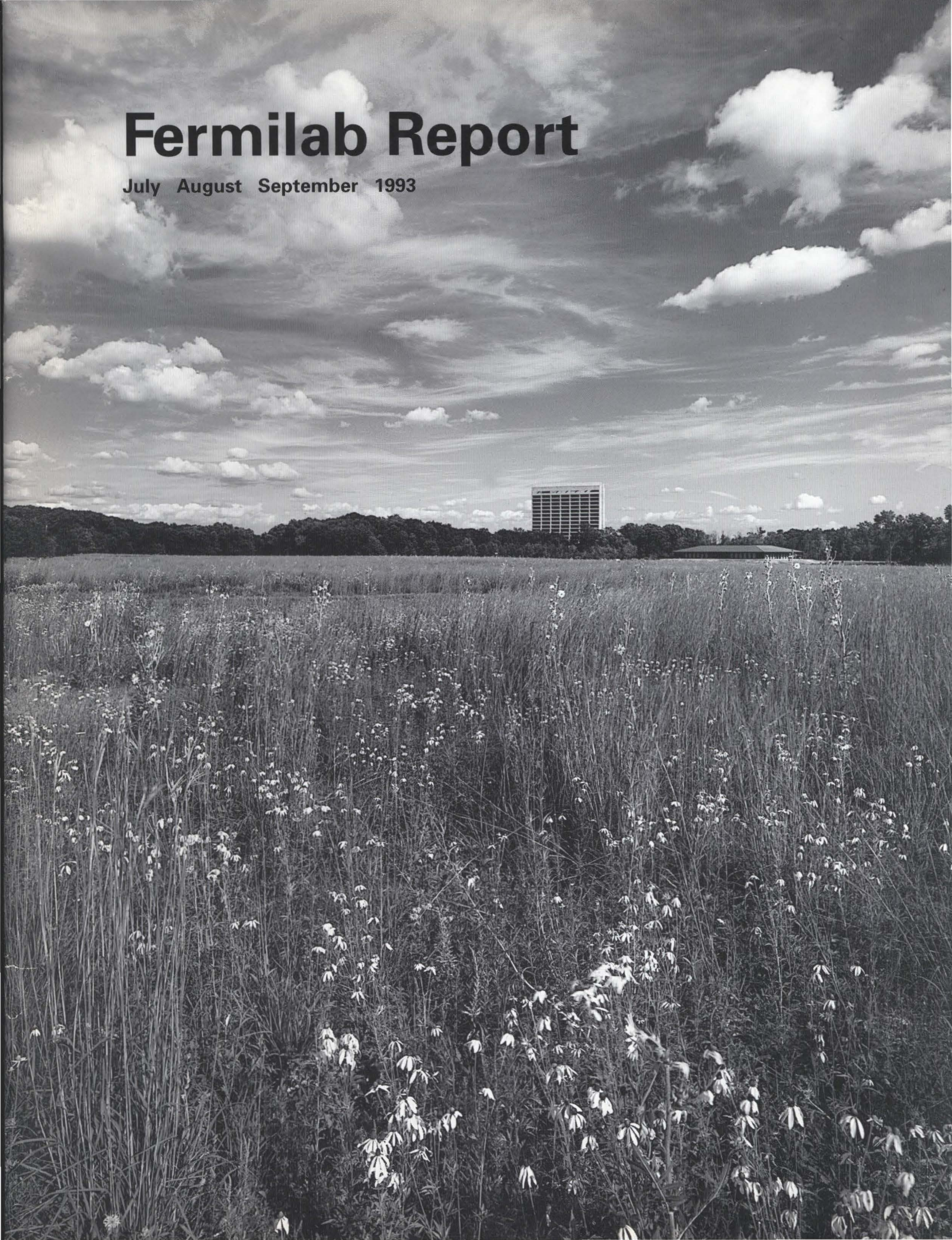
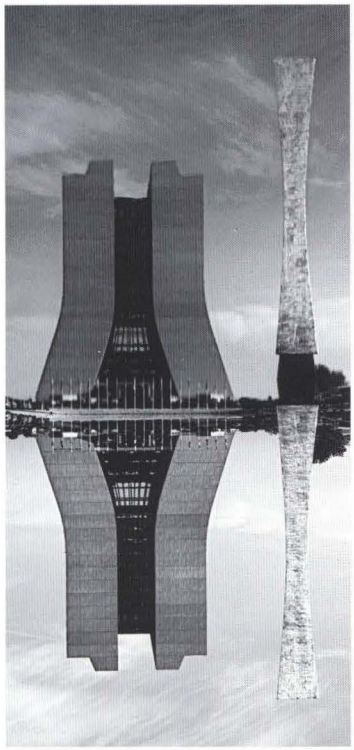
Fermilab Report

July August September 1993





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 largest 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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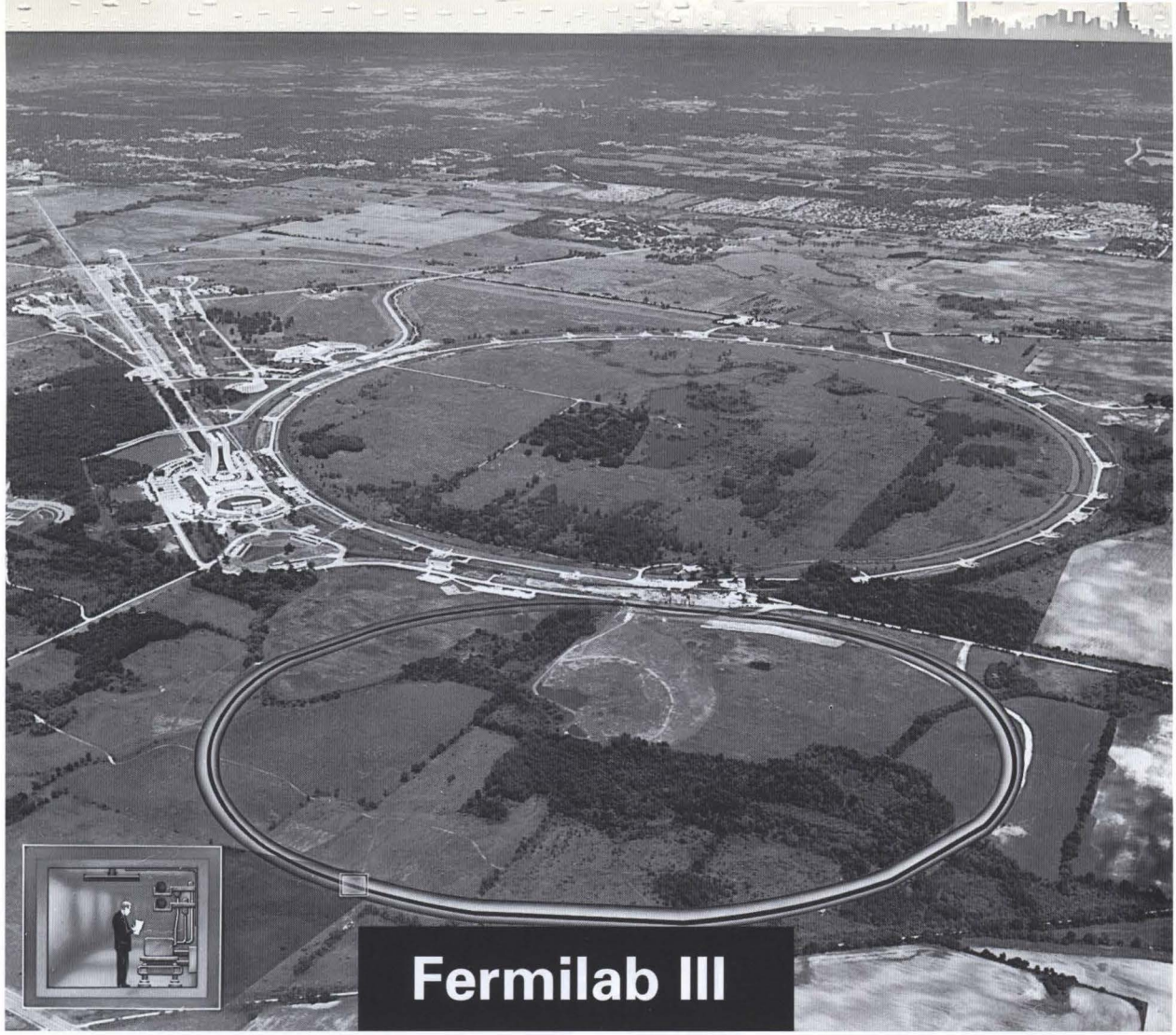


This issue of Fermilab Report gives an update on the progress of Fermilab III, a two-phase program of improvements now under way that will allow Fermilab physicists to do as much research in one year as they now do in five.

I

Our page 6 story highlights the first phase of Fermilab III, upgrading of the linear accelerator. The recently completed Linac Upgrade was commissioned on September 4 reaching its new design goal of 400 MeV in record time.

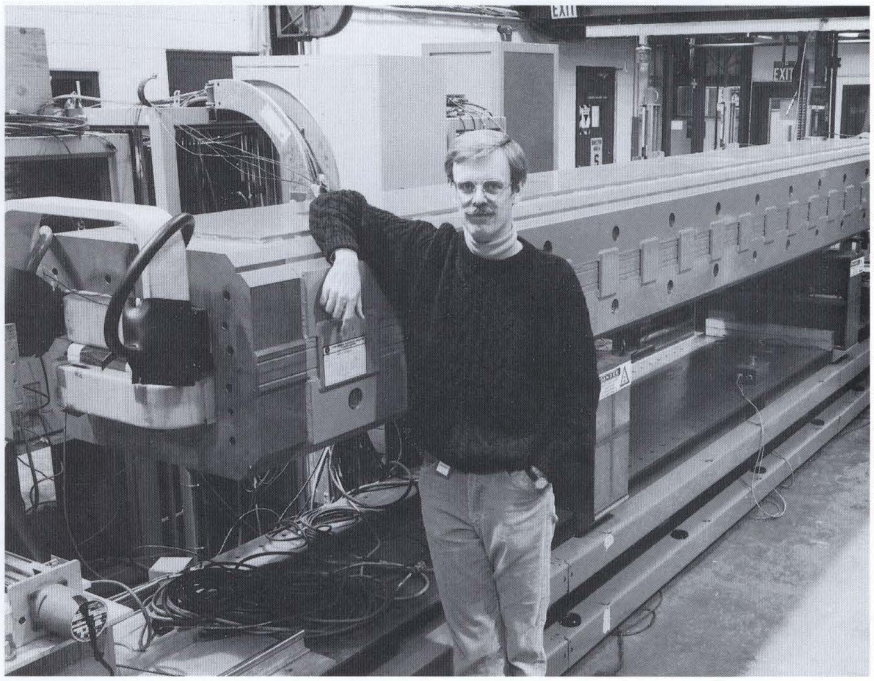
II

Construction has now begun on the most important component of the Fermilab III program, the Main Injector. The Main Injector will replace the nearly 25-year-old Main Ring and will keep U.S. high-energy physics at the forefront of the field. Our page 2 story gives a progress report.

III

Fermilab is now the largest, most active research laboratory in high-energy physics in the United States serving more than 2,000 U.S. and foreign researchers. The major improvements proposed in the Fermilab III program will give our Laboratory unique capabilities that will substantially strengthen the U.S. research program.

The Main Injector is the centerpiece to a series of major improvements underway at Fermilab.



Fermilab's Main Injector Moves from Vision to Reality

by Christopher Abraham

The Main Injector is the final piece of the Fermilab III program, an extensive series of upgrades that are intended to greatly improve the luminosity of the Tevatron. The Main Injector is designed to take the place of the nearly 25-year-old Main Ring, which is the major limiting factor in increasing the performance of the Tevatron. The Main Injector is designed to circumvent these limitations and significantly increase performance.

What is happening now?

Site preparation has already begun, with an extensive wetland mitigation project completed, a significant percentage of the below-grade construction nearest the Main Ring (called the MI-60 site) completed and the start-up of work on the largest of the Fermilab Main Injector service buildings, as well as electrical, water and access preparation for the injector ring enclosure itself.

This last project began in July under a contract with Martam Construction. This preparation includes most of the underground electrical and control conduit construction, various water systems around the FMI and provisions for temporary power on aerial lines. It also includes grading construction roads for access for enclosure construction.

Construction on the FMI ring enclosure should begin sometime in FY1994, contingent upon approval and funding from the Acquisition Executive Office of the Department of Energy.

New magnets for the FMI have been put through an extensive development and testing process by Accelerator Division and Technical Support Section staff, and are now at the stage where production can commence. Approximately 1000 conventional magnets will be needed for the FMI ring, of which 344 will be the new dipole design. The copper bending and insulating, as well as the steel die-cutting and lamination stacking into half-cores, will be done by outside contractors. Final assembly will take place on-site at Fermilab. Deputy Project Manager Dixon Bogert expects that the first production-level magnets will be seen by

Timeline of Main Injector Project

New Ring Study Group Reports	1987
1988	First Fermilab Main Injector conceptual design report completed
	R&D program begins in AD and TSS
HEPAP subpanel identifies Main Injector as top priority	1990
Environmental studies of Main Injector site begin	
1991	Outside architectual and engineering firm, Fluor Daniel, selected: Advanced conceptual design using State of Illinois Challenge Grant Funds begun
Completion of wetlands & floodplain mitigation	1992, Fall
1993, March	Below grade construction at MI-60 begins
Site-wide preparation construction begins	1993, July
1993, December (expected)	12 R&D dipoles complete, R&D dipole power supply to power test string of these magnets
FMI ring enclosure construction is expected to begin	1994 (expected)

the end of 1994.

In addition to the new magnets being constructed, the Main Injector will reuse a number of the magnets from the Main Ring. Nearly all the existing Main Ring quadrupoles will be refurbished for use in the injector ring, and some of the type B2 dipoles will be used in the beam transport line from the Booster to the Main Injector.

What is the origin of the FMI?

The concept of a replacement for the Main Ring has been around nearly as long as the Tevatron has been operational. The Main Ring was not engineered to serve as a penultimate accelerator, and with the installation of the CDF and then DØ detectors, the modifications necessary to the Main Ring's lattice have significantly reduced its efficiency.

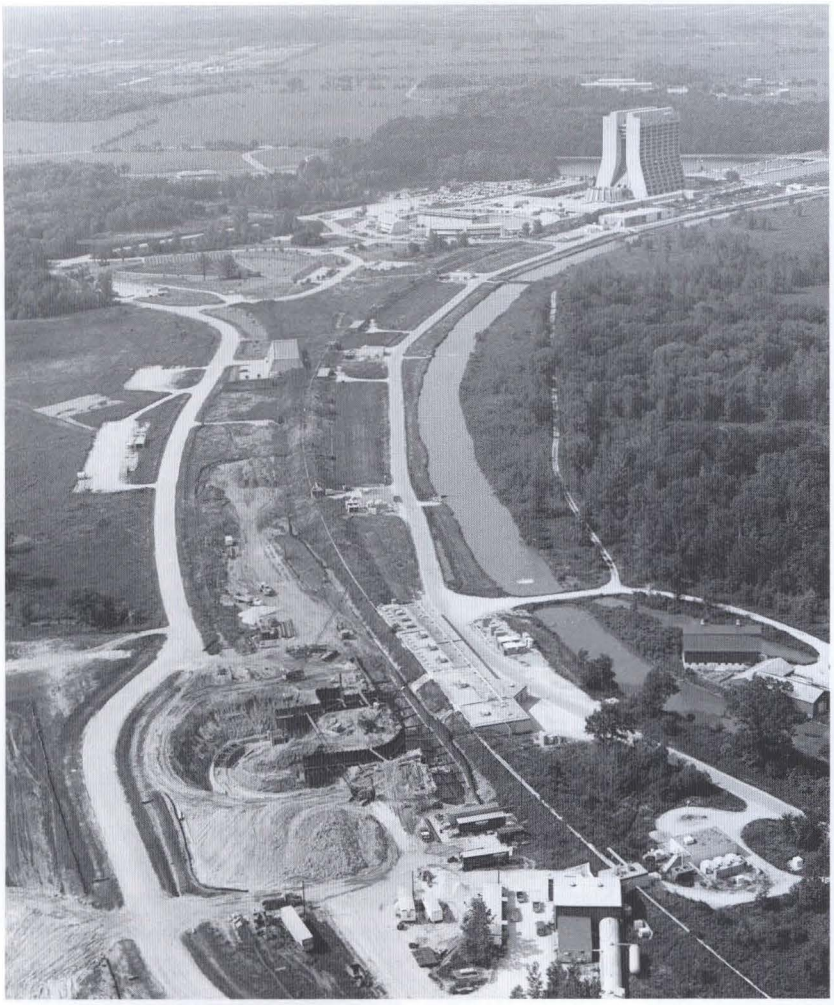
The first concrete suggestion of something that looked like a Main Injector was in a paper by Stephen Holmes, Gerald Dugan and John Marriner on the results of a New Rings Study Group that was formed in 1987. This group was specifically looking "into the need for and possibility of constructing new accelerators at Fermilab in support of the proposed upgrade of the proton-antiproton collider to a luminosity of $5x10^{31}$ $cm^{-2}sec^{-1}$" (the upgrade that was to become the Fermilab III program). They considered the construction of a new Main Ring only one of three options; the other two included construction of a new antiproton storage and/or recovery facility and the construction of a new Booster.

The present configuration of the Main Injector was chosen as the most viable option due to a number of factors. It solved several problems with the Main Ring, was cost efficient in comparison with other options, and was found to be more necessary to improved collision rates than originally thought. The reason for this was that antiproton stacking rates were not very well understood at the time of the initial study, and were overestimated by a factor of two and a half. The Main Injector is designed to bring the stacking rate up to original estimates.

What was the development of the FMI?

The location of the Main Injector was influenced by a number of factors. The choice of possible locations was limited by the need for close proximity to the Main Ring/ Tevatron enclosure. Other major concerns included environmental and radiological shielding considerations. After an extensive review of the various factors, the present site in the southwest quadrant of the Fermilab site was chosen, with the point of closest proximity to the Main Ring being at the F0 area.

After plans for the specific site were developed, two different and important review processes had to take place. The first of these was an Environmental Assessment. This review was necessary to demonstrate that there would be "no significant impact" on the environment due to the construction and operation of the Main Injector. In July of 1992 the Department of Energy accepted this review and a final "Finding of No Significant Impact" was published. Included in this statement were plans for wetland and floodplain mitigation, review of the plant and wildlife



Aerial view of MI-60 enclosure excavation.

impact and review of some aspects of radiological concerns. The Wetlands Mitigation Project was begun shortly after the publication of the FONSI and was completed earlier this year.

The second review process involved safety analysis and resulted in the submission to DOE of the Preliminary Safety Analysis Report. This document addressed radiological, fire, electrical and construction safety aspects. Safeguards and procedures outlined in the PSAR have since been accepted by the reviewing staff at DOE.

What is the funding history of the FMI?

Congress first appropriated funding for FMI in FY1992 to the extent of $15M, but reduced this later to $11.65M. This funding was in itself a significant move forward, however, and the project has continued to receive the highest level of support from both DOE and its High Energy Physics Advisory Panel (HEPAP). The HEPAP Subpanel on U.S. High Energy Research gave the FMI project its second-highest priority (behind the SSC) in 1990 and again in 1992.

An additional $15M was appropriated for FY1993. Roughly 10 percent of the total project cost has been appropriated, and funding is the major constraint on the project at present. The latest DOE/ER review of the project in March of this year stated that the Fermilab Main Injector could easily and responsibly commit $75M for FY1994. However, the current presidential budget request shows appropriations of only one-third this amount.

Unless some relief from budgetary constraints are obtained, project completion could be extended another 13 months, into late 1998. Despite these constraints, the project is moving forward and has the support of DOE and Congress.

Wetland Mitigation Complete

The Department of Energy requires that Environmental Assessments address several possible environmental dangers. One concern is the destruction of wetlands. Federal law requires that developers must replace any wetlands damaged or destroyed at a ratio of 1.5 to 1. Destruction of wetlands is covered by the Clean Water Act.

Construction of the Fermilab Main Injector will alter approximately six acres of wetlands, so the mitigation project created nine acres of new wetlands inside the circumference of the FMI ring. Monitoring of the created wetland area will continue for five years.

What are the performance advantages of the FMI?

As stated earlier, the need for the Main Injector stems from the inefficiency of the Main Ring. When the Main Ring was reconfigured to provide support for the Tevatron, vertical overpasses were added around the CDF and DØ interaction regions and several new extraction areas were added for antiproton operations. These modifications reduced the effective aperture of the Main Ring to the point where the Booster now only runs at about two-thirds its capability during normal operation. With the installation of the Linac Upgrade, the Main Ring will present even a greater bottleneck in injection rates into the Tevatron.

The Main Injector is designed to have a transverse aperture of 40 π mm-mr, larger than that of the Booster (30 π mm-mr now that the Linac upgrade is complete). In comparison, the Main Ring has an effective aperture of only about 12 π mm-mr. The Main Injector should be capable of accelerating 5×10^{12} protons per Booster batch for antiproton targeting, as compared to 1.7×10^{12} by the Main Ring, and delivering 6×10^{13} protons to the Tevatron, as compared to the Main Ring's 1.8×10^{13}. It is also anticipated that the Main Injector will cycle more rapidly, improving from 2.6 seconds to 1.5 seconds.

The major impact of this increased performance and improvements in field quality and physical beam sizes will be an increase in luminosity by a factor of five to 10. This, along with the elimination of background interference at the CDF and DØ detectors will mean major increases in the integrated luminosity seen by the collider detectors. Also, by eliminating the Main Ring from the accelerator cascade and keeping the F section of the Main Ring magnets for transport of beam to the fixed-target areas, collider and intermediate-energy fixed-target experiments will be able to operate simultaneously.

FMI project management is very encouraged by the progress of the project to date. Formal groundbreaking was held on March 22, 1993. Progress on all civil and technical design and R&D efforts has been rapid given the available funding and rate of approval.

Fermilab is anxious to complete the Main Injector and provide the research community with the advantages of an accelerator facility that has found greater efficiency and a new vitality. ■

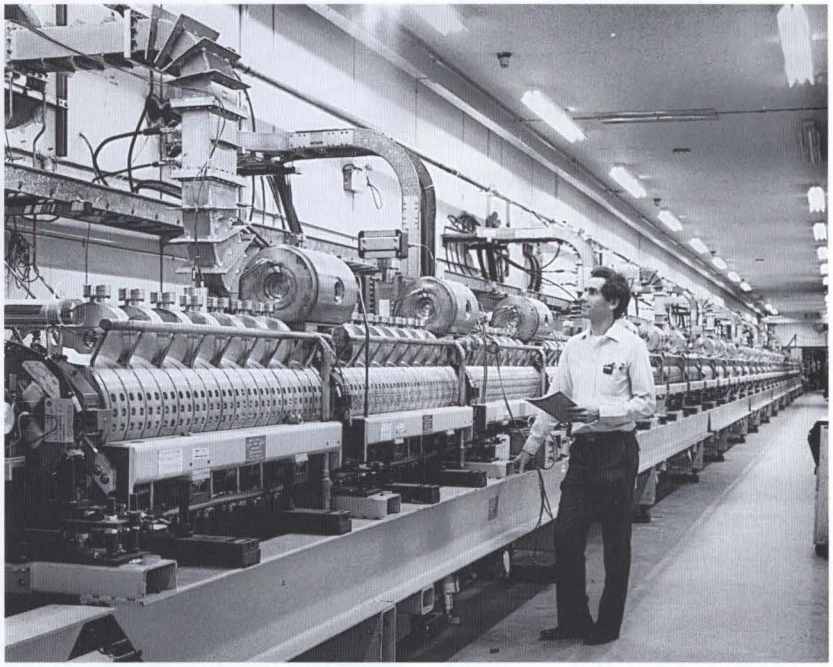
A construction worker inspects the Main Injector rf straight section.

Page 1 photo: an artist rendering of the Fermilab Main Injector.

Page 2 photo: Stephen Holmes, head of the Accelerator Division, poses with one of the conventional iron-core magnets that will be used in the Fermilab Main Injector.

There will be a total of 344 magnets including 216 six-meter dipoles weighing 17,000 kilograms each and 128 four-meter dipoles weighing 12,000 kilograms each. Operating at a maximum of 9,375 amperes, the magnets will be capable of generating a magnetic field of 1.73 tesla. Fermilab designed these magnets and transferred the technology to industry to build the components.

After 23 years of nearly 100% reliable service, four of the nine original Linac drift tube tanks have been replaced.



Laboratory Commissions Recently Upgraded Linac

by Christopher Abraham

After 23 years of nearly 100% reliable service, four of the nine original Linac drift tube tanks were replaced this summer. This was the first step in the Linac Upgrade Project, which was designed to double the final beam energy out of the Linac from 200 MeV to 400 MeV and consequentially create a 75% increase in the number of particles sent down to the Booster. The increase in the Booster intensity is due to a reduction in the tune spread from beam space-charge forces at Booster injection. This will produce a higher luminosity in the Tevatron, and is the first phase of the accelerator upgrades that will eventually culminate in the commissioning of the Main Injector.

The 400 MeV Linac began as a conceptual design in 1987, about the same time that the Main Injector was conceived and Fermilab III was taking shape. The goal of the design was to achieve 400 MeV in the existing space by increasing the acceleration gradient from 2.5 MV/meter to 7.5 MV/meter (at that time considerably higher than any operating proton linac) and increasing the frequency from 201.15 MHz to 805 MHz .

Even back in the late 1960s, there were better known ways to accelerate protons, once they had reached energies of 100 MeV or so, than the drift tubes of the Linac. The original decision to use the same system up to 200 MeV was one of simplification—it was easier to make one consistent accelerator than to add another piece to an already complex puzzle. With the desire to double the Linac injection energy, however, it was decided that the time had come for a new system.

Initially, the Linac group examined several structures including both the side-coupled cavity structure and the disk-and-washer structure. After prototyping these two alternatives, side-coupled cavity accelerators, based on the Los Alamos LAMPF experience, were chosen as the most viable solution for design considerations.

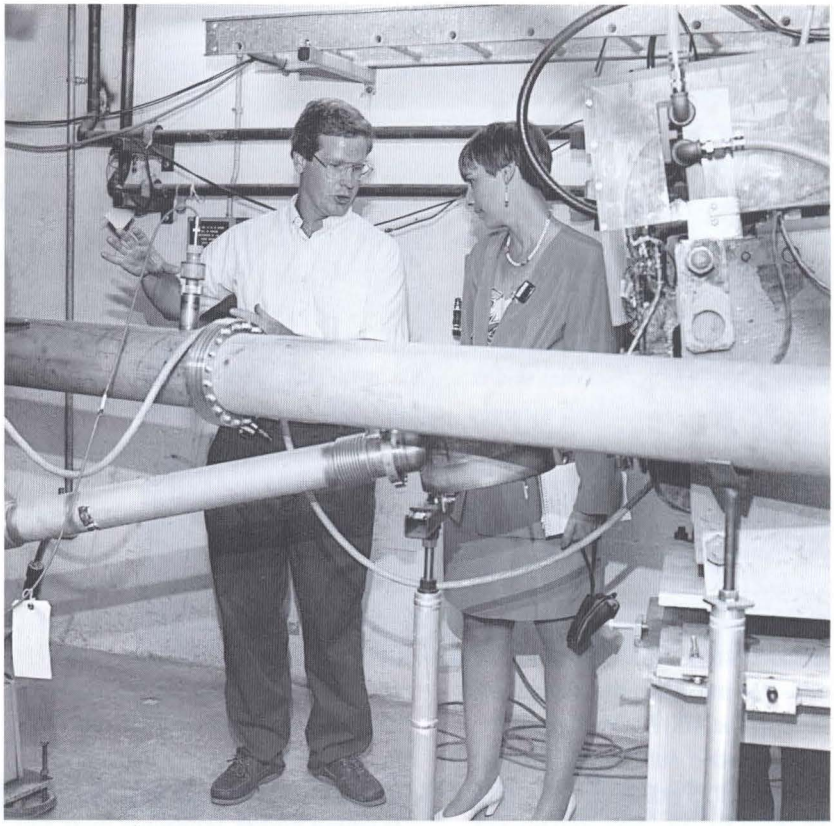
In place of the last four Linac drift tubes cavities now are seven modules of newly produced side-coupled cavity accelerators. Each of the six- to 10-meter-long modules

are made up of four sections, and each section is in turn a collection of 16 individual cells. Along with a transition section for matching the beam between the old and new accelerators and a space of about two meters at the downstream end of the new Linac for Linac-to-Booster transfer line changes, the new accelerators fit into the 66-meter space left when the drift tubes were removed in June.

With an average axial field of 7.5 MV/m, or about three times the gradient in the existing drift tubes, a considerable concern for the design was high sparking rates causing erratic beam pulses and unreliable injection operation. For the Linac Upgrade it was considered desirable to limit the spark rate to one spark per thousand rf pulses, corresponding to at most 0.1% beam loss due to sparking. All modules were voltage conditioned at full power and spark rates were below the 0.1% target. The spark rate continued to improve during operation in the Linac tunnel.

Bob Noble, project manager for the upgrade, said that the installation and commissioning went remarkably well this summer. He explained that the only serious difficulty were delays in the repair of faulty transformers for the power supplies. But, he said, Fermilab engineers worked with the manufacturer to assure finished transformers before commissioning, which began August 27.

Noble said the commissioning of the Linac was "more successful than anyone thought it would be." Commissioning began by achieving a low-intensity beam in the remaining drift tubes. This beam, about 1% of normal operation, was studied using beam current toroids, loss monitors, wire scanners, rf beam-position monitors and trim steering magnets. The beam was matched and adjusted with the transition section first, then the accelerating modules were turned on and tuned.



David McGinnis, 400 Mev Commissioner and head of the Booster Department, discusses the recent Linac upgrades with Cherri Langenfeld, head of DOE Chicago Operations Office, during the Accelerator Readiness Review. McGinnis coordinated the day-to-day commissioning projects and was responsible for seeing that commissioning issues were resolved by the subproject manager. He was assisted by Chuck Schmidt, head of the Linac Department, who was responsible for the commissioning phase of the installation for the Linac Department.

The commissioning ran smoothly and quickly, said Noble. On August 30, beam was accelerated through the first of the seven modules at approximately 152 MeV. Then on September 4 at approximately 3 a.m., beam was accelerated through module three to 220 MeV. The Linac reached its new design energy goal of 400 MeV at nearly 3:30 p.m. on September 4. The transmission through the Linac was roughly 80% transmission, which, according to Noble, was a very acceptable first pass through the Linac. The shielding was reassessed along the downstream end of the Linac tunnel September 8, completing the first leg of the commissioning.

Commissioning continued for four weeks. The final stages of commissioning were coordinated with the Booster group, which was responsible for commissioning the

new beam transport section to the Booster and matching the Booster to the new 400 MeV beam from the Linac.

The original Linac has gone through some substantial changes in the past 23 years, but none as extensive as what was done this summer. Noble explained that there have been several changes in the support hardware for the Linac, but that this is the first time since it was commissioned in 1970 that any substantial beamline hardware has been replaced. "The Linac went through some changes when we switched from using protons to negative hydrogen ions," Noble said, "and the control hardware was replaced in the mid-70s and again just recently to support the 400 MeV upgrade."

Another substantial change came in 1975 when the Neutron Therapy Facility was constructed. The Linac serves as the source accelerator for this unique treatment facility. Space was created between two of the drift tube tanks to allow beam to be magnetically bent and rerouted to the treatment room. At this time, neutron therapy was an experimental treatment for certain types of cancer. The patient histories gathered at the NTF helped move this treatment from experimental into an acceptable, conventional form of treatment for certain types of cancer. The NTF was largely unaffected by the Linac upgrade since the treatment beam is taken out of the accelerator upstream from the new modules.

This project is of great importance to the Laboratory's physics program and the success of the Fermilab III project. Not only is it important to have the new Linac accelerating in time for the second half of the present collider run, but the increased intensity expected from the Linac will be significant in reaching higher antiproton rates and in substantially increased luminosity after the completion of the Main Injector. ■

Photo page 5: Bob Noble conducts a final inspection of the new Linac prior to its commissioning. Noble is standing in front of Module One, the first accelerating point of the new Linac.

At the far left of the photo, before Module One, is the transition section, the point where beam enters the module from the remaining drift tube tanks. Above his head is the first of seven waveguides along the Linac. The waveguides guide rf waves from the klystron to the accelerator module.

The contributor

Christopher Abraham served a summer internship this year in the Fermilab Publications Office. He has a B.S. in English and physics from Hillsdale College in Michigan. He is currently pursuing a master's degree in Technical and Scientific Communication from Miami University, Oxford, Ohio. ■

Linac completes accelerator readiness review

The recently commissioned Fermilab Linear Accelerator passed the first stage of a Department of Energy Accelerator Readiness Review and Fermilab personnel are preparing for the final stage.

An accelerator readiness review is required for any new or upgraded accelerator by the Department of Energy under DOE Order 5480.25 *Safety of Accelerator Facilities*. The order was written to ensure that accelerators pose no safety, health or environmental threat during commissioning and routine operation.

Under this order, an accelerator cannot be turned on for commissioning or routine operation until permission has been granted by DOE. Permission is based upon an acceptable readiness review.

The review process calls for an evaluation of the accelerator by field experts who are not directly involved in the project. The Fermilab Linac Upgrade Project was reviewed by individuals from the Department of Energy, Brookhaven, CEBAF, the SSC Laboratory and Fermilab.

The result of an accelerator readiness review is a set of issues identified by the review committee. The Fermilab review took place in June. Approval for commissioning the accelerator came in August.

"Final approval is based on two criteria," said David Finley, deputy head of Fermilab's Accelerator Division. " First, DOE, through its review processes, must accept that the operation of the accelerator represents a low safety risk. Second, DOE must be satisfied that all issues identified during the review have been satisfactorily resolved."

Following a successful commissioning review, the Laboratory is now preparing for the final stage of approval prior to initial operation. ■

A small Fermilab experiment produces data that contributes significantly to our understanding of antimatter.

Search for Antiproton Decay at the Fermilab Antiproton Accumulator

by Stephen Geer

In May 1992 one of the smaller experiments at Fermilab quietly collected data at the AP50 region of the Fermilab Antiproton Accumulator. The experiment was T861, and its purpose was to measure trigger rates and background properties in preparation for a future experimental search for antiproton decay. T861 exceeded these original goals by producing interesting results in its own right which contribute significantly to our experimental knowledge of the intrinsic stability of antimatter. [1]

The CPT theorem requires that the antiproton lifetime $\tau_{\bar{p}}$ equals the proton lifetime which we know exceeds 10^{32} years. In practice we can only hope to observe antiproton decay if $\tau_{\bar{p}} << 10^{32}$ years ... so why search for antiproton decay? Because CPT is one of the most fundamental theorems of modern physics, and it is impor-

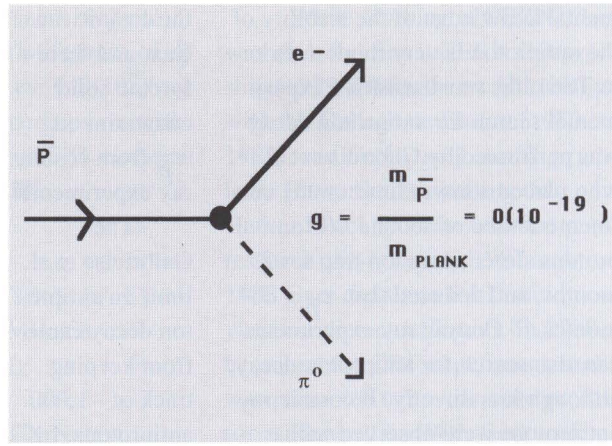


Figure 1: Example of a CPT violating process that would result in antiproton decay with a coupling that is linear in mass and arises from physics at the Plank scale.

tant to test it in as many ways as possible. Furthermore, there are some related open questions; we do not at present fully understand the origin of CP violation, neither do we fully understand the origin of matter dominance in the universe. Let us imagine a CPT violating coupling that results in antiproton decay, $\bar{p} \rightarrow e^- \pi^0$ for example (Fig. 1). If the coupling were to be linear in mass and arise from physics at the Plank scale, we might guess that the coupling constant $g = O(m_{\bar{p}}/m_{\mathrm{PLANK}}) \sim 10^{-19}$. If we know the nature of the coupling then we can calculate the resulting antiproton decay rate. Perhaps the simplest case is to consider a pure scalar or pseudoscalar interaction, in which case the partial width $\Gamma(\bar{p} \rightarrow e^- \pi^0) = 2x10^{-40}\,\mathrm{GeV}$ [2]. The resulting lifetime $\tau_{\bar{p}}/\mathrm{BR}(\bar{p} \rightarrow e^- \pi^0) = 10^8$ years, which is only O(1%) of the age of the universe. It is easy to see how such a process, if it were to exist, might have something to do with matter dominance in the universe.

A second reason to search for antiproton decay is that our experimental knowledge of the stability of the antiproton is very modest. Prior to T861, the most sensitive experimental search for antiproton decay was performed by Gabrielse et al., who placed a lower limit on the confinement time of about 1,000 antiprotons stored in an ion trap for 2 months, and deduced that $\tau_{\bar{p}} > 3.4$ months. [3] Cosmic ray experiments can also search for antiproton decay, although less directly. If cosmic ray antiprotons were observed with a rate consistent with secondary production in the interstellar medium we could infer that $\tau_{\bar{p}}$ was at least as long as the confinement time in the galaxy, which is calculated to be O(10^7) years. Allowing for experimental and theoretical uncertainties, we might expect the resulting limit to be O(10^6) years. However, at present there is no confirmed observation of antiprotons in the cosmic ray flux, and therefore no solid constraint on $\tau_{\bar{p}}$ from cosmic ray experiments.

The Galbrielse et al. limit on antiproton decay came from keeping track of ~1,000 antiprotons. In the Fermilab Antiproton Accumulator typical stores contain O(10^{12}) antiprotons, offering the possibility of searching for antiproton decay with greatly improved sensitivity. The T861 experiment, which consisted of (Fig. 2) a 5-meter-long beampipe, the forward electromagnetic calo-

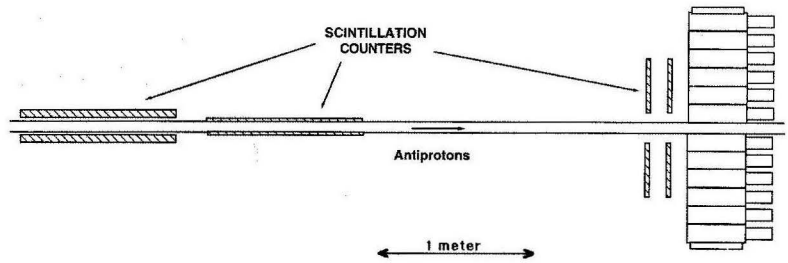


Figure 2: Schematic of the T861 experiment at the Fermilab Antiproton Accumulator.

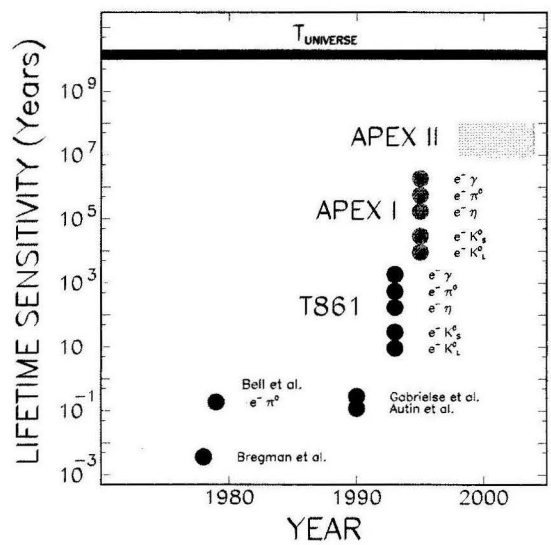


Figure 3: Searches for antiproton decay: past and present results and future expectations. T861 is the experiment that ran in 1992 at the antiproton accumulator, and is described in this article. APEX I is the E868 experiment at the antiproton accumulator that is due to run in 1994. APEX II is the imagined ultimate experimental search for antiproton decay at the Antiproton Accumulator.

rimeter from the old E760 experiment, and some additional scintillation counters, searched for antiprotons decaying in a straight section of the antiproton accumulator ring. The search was for two-body decays of the antiproton in which the decay products deposit all of their energy in the calorimeter. The experiment therefore searched for events in which there were two calorimeter clusters, well balanced with respect to the beam axis (reflecting transverse momentum conservation) and with a total energy close to the antiproton beam energy of 8.9 GeV. T861 recorded 6.8 million events, whose rate and properties were well described by Monte Carlo predictions for interactions of antiprotons with residual gas inside the beampipe. After applying suitable cuts on calorimeter cluster multiplicity and energy balance, only a few events survived. The absence of a peak in the total energy distribution at the beam energy enabled limits to be placed on five antiproton decay modes (Table 1). The most stringent limit is on the decay $\bar{p} \rightarrow e^- \gamma$ for which, at the 95% confidence level, $\tau_{\bar{p}}/\mathrm{BR}(\bar{p} \rightarrow e^- \gamma) >$ 1848 years.

T861 was only the beginning. Based on the experience gained from T861, in September 1992 the APEX (Antiproton Experiment) collaboration proposed an upgraded detector to improve on the sensitivity of the T861 search by three orders of magnitude, and to extend the search to cover additional decay modes. The new search for antiproton decay has been approved as experiment E868. The APEX detector is currently under construction, and due to be installed and take data during 1994.

The future of antiproton decay searches at Fermilab looks rosy. Figure 3 compares past and present limits on antiproton decay with our expected future sensitivity. T861 has already improved the experimental limit on some decay modes by three orders of magnitude. The approved E868 experiment (APEX stage I) should further improve the sensitivity by a similar factor. Beyond E868 we imagine an APEX stage II experiment, the ultimate search at the Fermilab Antiproton Accumulator. Experience from E868 will help us to understand what the ultimate sensitivity is likely to be. At present we hope that in the long-term it will be possible to achieve a sensitivity to antiproton decay with lifetimes of up to $O(10^7)$ or maybe even $O(10^8)$ years. Who knows, perhaps we will even find evidence for CPT violation at the Plank scale! ■

Mode	Limit (95% C.L.)
$\bar{p} \rightarrow e^- + \gamma$	1848 years
$\bar{p} \rightarrow e^- + \pi^0$	554 years
$\bar{p} \rightarrow e^- + \eta$	171 years
$\bar{p} \rightarrow e^- + K_S^0$	29 years
$\bar{p} \rightarrow e^- + K_L^0$	9 years

Table 1:Limits on $\tau_{\bar{p}}$/BR for five decay modes of the antiproton.

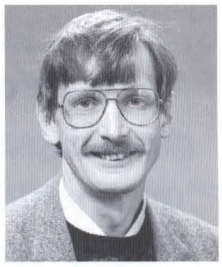
References

[1] S. Geer et al. (T861 Collab.), FERMILAB-PUB-93/315-E.

[2] B. Corbin, APEX Note 4, 1993 (unpublished).

[3] G. Gabrielse et al; *Phys. Rev. Lett.* **65** (1990) 1317.

The Contributor

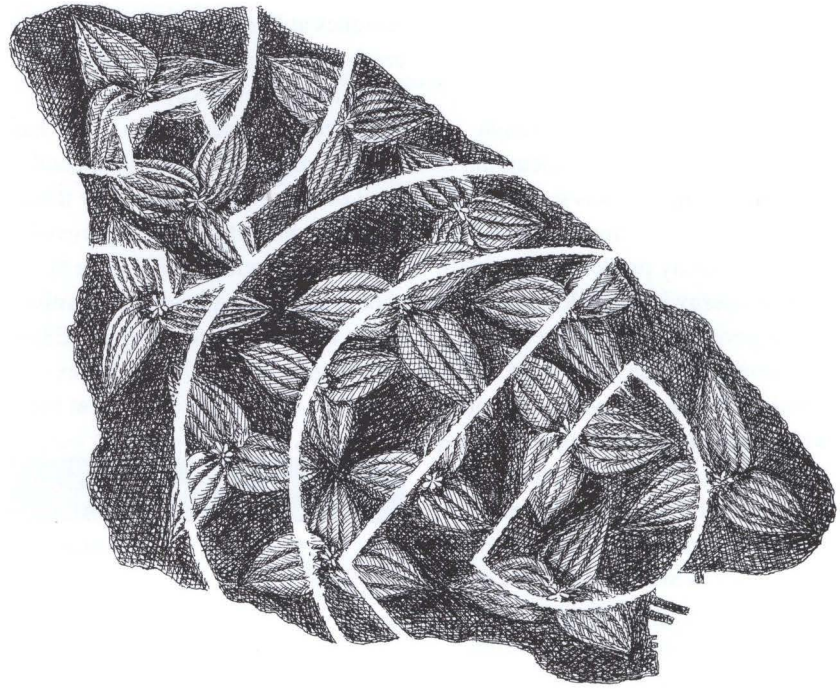


Stephen Geer is spokesperson for T861 and E868. His thesis experiment was a study of Kaon production in π^-p interactions at 16 GeV/c at the CERN OMEGA spectrometer. He obtained his Ph.D. in 1980 from the University of Liverpool, England.

During the period 1979-1988 Geer worked on the UA1 experiment at CERN. He was involved in a broad range of UA1 activities, ranging from R&D on modifying and using a betatron as a calibration device to working on the central track chamber readout electronics, coordinating the event scanning effort on UA1, and doing a variety of analysis. Perhaps his most noteworthy contribution was the central role he played in the discovery of the *W* and *Z* bosons, coordinating the UA1 *W* and *Z* Analysis Group, and writing many of the papers on the *W* and *Z* results from UA1.

While working at CERN, Geer was awarded first a CERN fellowship (1979-1980), then a fellowship with the College de France (1980-1983), and finally he joined a group from Harvard, after joining the Harvard Faculty as an assistant professor in 1987. During 1987 and 1988 Geer did some R&D on ion yields in dielectric liquids. In 1988 he joined the CDF experiment, and was promoted to an associate professor at Harvard in 1989. Geer took a permanent position at Fermilab in 1990, and since that time has been responsible for leading the CDF offline activities. ■

The collaboration has now grown to 17 senior research physicists from eight universities and two national laboratories.



CTEQ: An Experiment in Collaborating

by Jorge G. Morfín for the CTEQ Collaboration

The concept of forming a collaboration consisting of both experimentalists and theorists is not new. When the structure of experimental collaborations was less formal and the very distinction between "theoretical" and "experimental" physicists was somewhat vague there were often collaborations freely mixing the two types of physicists. More recently, large collaborations formed for the SSC attracted theorist collaborators for a variety of goals such as ensuring that the Monte Carlos used to design the detector were reflecting the latest knowledge of the physical processes being modeled. However, these collaborations were essentially huge groups of experimentalists designing and constructing an experiment with a few theorists. The "Coordinated Theoretical/Experimental Project on Quantitative QCD Phenomenology and Tests of the Standard Model" (The CTEQ Collaboration) was specifically formed with the idea to invite theorists and experimentalists to work together in assessing the open problems of QCD from their various unique perspectives in order to accomplish particular common goals.

Of the many roads leading to the eventual establishment of the CTEQ collaboration, one of the most direct was the joint project started by the theorist Wu-Ki Tung and the author, an experimentalist, on global QCD analysis and the determination of parton distribution functions. [1] This effort demonstrated the effectiveness of this type of collaboration and attempts were made to expand the project to include other theorists and experimentalists active in QCD analysis. At the time, problems arose when trying to find a source of funding for such a unique type of collaboration since there was no way to categorize it and, consequently, no budget director willing to commit financial support to such a venture. The formation of the Texas National Research Laboratory Commission (TNRLC) to promote physics research directed toward SSC energies provided a welcome new source of less restrictive funding. In October 1990 the initial CTEQ group of six theorists and four experimentalists

submitted a "theory" proposal, with Wu-Ki Tung as spokesman, to TNRLC. The proposal was favorably reviewed and CTEQ became a funded collaboration.

Although the collaboration has now grown to 17 senior research physicists from eight universities and two national labs, the goals of the collaboration are essentially the same as initially formulated:

a) **To promote knowledge of QCD among the younger generation of high-energy physicists by sponsoring a summer school on QCD Phenomenology and Analysis.**

With essential personnel support from Fermilab (Treva Gourlay and Suzanne Weber in 1992, Cynthia Sazama and Pat LaVallie this year), the CTEQ Summer School on QCD Analysis and Phenomenology has taken place the last two summers. Out of a total of over 250 applicants, 170 participants were selected coming from the U.S., Europe, Latin America and Asia. With the generous financial support of TNRLC and Fermilab it was possible to keep the cost for subsidized participants very low so that limited group funding levels did not necessarily have to be part of the decision to participate.

The school is based on close contact between instructors and participants with a typical day including four hours of class, one-two hours of recitation and a concluding "nightcap" where participants can continue discussions on an informal basis with the instructors. The courses offered at this past summer's school included:

- Introduction to the Parton Model and Perturbative QCD
- QCD Phenomenology and Experimental Reviews of:
  - Deep Inelastic Scattering
  - Lepton-pair / W-Z-Production
  - Direct Photon Production
  - Jet Production
  - Heavy Quark Production
- The Practice of Perturbative QCD
- Small-x Physics
- Physics and Techniques of Event Generators
- QCD and Precision Tests of the Standard Model
- Review of Global QCD Analysis
- Pomeron Physics
- Determination of α_S

The reviews of the school by the participants have been overwhelmingly positive. The community has demonstrated its approval of this school through additional offers of financial support from U.S. and European institutions.

b) **To encourage the dissemination of useful and practical knowledge on QCD applications among the entire high-energy community by compiling a Handbook on QCD.**

There exists an enormous published work on QCD calculations of various high-energy processes. Within this collection, however, there is a confusing variety of notations and renormalization/factorization scheme dependencies of the hard-scattering cross sections and parton distributions employed. This makes it very difficult to compare results and to apply them in a consistent manner.

The CTEQ Collaboration undertook a systematic review of these QCD calculations and phenomenological applications as well as the relevant experimental data. The results of this review are contained in Version 1.0 of the CTEQ Handbook on Perturbative QCD which was published by Fermilab. [2] Over 850 copies have been requested by the community.

c) **To perform a comprehensive global analysis of available experimental data to test the accuracy of perturbative QCD predictions and to extract the universal parton distribution functions.**

A publication describing the CTEQ1 parton distribution functions has appeared and the updated CTEQ2 set of functions, which include the recent HERA deep inelastic scattering results, has been distributed. [3] The members of the CTEQ global fitting subgroup are in the process of preparing a long write-up of the CTEQ2 results and a description of the CTEQ methodology of global QCD analysis.

d) **To apply the QCD parton model framework systematically to a wide range of high-energy processes.**

In addition to the global analysis mentioned above, the following topics are being addressed by subgroups of CTEQ consisting, in most cases, of experimentalists working on the analysis and theorists performing the relevant theoretical calculations or developing Monte Carlo programs:

- Heavy quark production in deep inelastic scattering
- Direct photon production: fixed target and collider experiments
- *W-Z-* production and precision determination of M_W
- Jet cross sections: collider and deep inelastic scattering
- Rapidity gap physics
- Resummation, small-x physics

and heavy flavor production
- Higgs physics
- Higher-twist effects
- Polarization phenomena in QCD
- Nuclear effects in deep inelastic scattering

CTEQ had gone back to TNRLC for two successful renewal applications and was preparing the funding proposal for a fourth year when the defeat of the SSC in the U.S. House of Representatives changed the face of U.S. high-energy physics. The collaboration met at the end of October to determine how to proceed. The desire to continue working as a single directed effort was unanimous. It was agreed to submit a combined "CTEQ Proposal" (as opposed to 10 individual institutional requests) to the traditional funding agencies for future funding of the Collaboration. In the spirit of this decision, plans for the 1994 CTEQ Summer School on QCD Analysis and Phenomenology have already begun. In addition, the assignments for an expanded Version 2.0 of the handbook, involving additional chapters as well as supplements to existing chapters and sections, have been distributed among the collaboration and should be ready by the summer of 1994.

An additional important activity of the CTEQ collaboration will be the organization of a series of mini-workshops emphasizing the rich selection of physics still to be explored at Fermilab collider and fixed target energies. They will be scheduled to coincide with future CTEQ collaboration meetings. The first in this series, "QCD at 2 TeV", was organized by the Michigan State University contingent of CTEQ and took place at M.S.U. directly following our latest CTEQ collaboration meeting. The extensive interaction between theorists and CDF and DØ experimentalists generated by the talks and informal format proved extremely productive for all groups.

As an experiment in collaborating, CTEQ has been a very fruitful and rewarding success. The financial support of the Texas National Research Laboratory Commission was crucial to both the formation of this collaboration and to its subsequent achievements. We most gratefully acknowledge their sponsorship. ■

CTEQ Collaboration Members and Affiliations

Raymond Brock, Michigan State University	Jianwei Qiu, Iowa State University
John Collins, Pennsylvania State University	Jack Smith, SUNY Stony Brook
Joey Huston, Michigan State University	Davison Soper, University of Oregon
Steve Kuhlmann, Argonne National Laboratory	George Sterman (co-spokesperson), SUNY Stony Brook
Sanjib Mishra, Harvard University	Wu-Ki Tung (co-spokesperson), Michigan State University
Jorge G. Morfin, Fermilab	Harry Weerts, Michigan State University
Fred Olness, Southern Methodist University	Jim Whitmore, Pennsylvania State University
Joseph Owens, Florida State University	C.P. Yuan, Michigan State University
Jon Pumplin, Michigan State University	

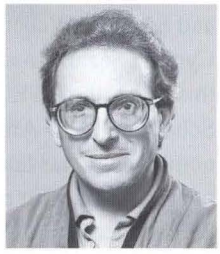
References

[1] Parton Distributions from a Global QCD Analysis of Deep Inelastic Scattering and Lepton Pair Production. Jorge G. Morfín and Wu-Ki Tung. Z. Phys. **C 52**, (1991) 13.

[2] Handbook of Perturbative QCD, by The CTEQ Collaboration, G. Sterman editor. Fermilab-PUB-93/094, April 1993. (to be published in Rev. Mod. Phys)

[3] CTEQ Parton Distributions and Flavor Dependence of Sea Quarks. J. Botts et al. Physics Letters **B304**, 159 (1993).

The contributor



Jorge G. Morfín is a Fermilab staff physicist coordinating long-range planning of fixed-target experiment installation. In addition to his participation in CTEQ, he is involved in E665, Tevatron muon experiment, and E803, neutrino oscillation experiment.

Morfín has had a long-standing interest in helping the development of physics research and education in third-world countries and was chairperson of the International Physics Group of the American Physical Society. He is currently a member of the Committee on International Scientific Affairs of the A.P.S. He is a member if the Fermilab Auditorium Committee and chairs the Fermilab Minority Internship Committee. ■

Lab Notes

Awards

Landmark Status for Fermilab's Tevatron

On September 27, the cryogenic cooling system of Fermilab's Tevatrón was designated an International Historic Mechanical Engineering Landmark by the American Society of Mechanical Engineers. Dignitaries from the ASME, Fermilab and the U.S. Department of Energy, which funds Fermilab, gathered for the afternoon ceremony at the Laboratory.

Fermi National Accelerator Laboratory is the site of the Tevatron, the world's first high-energy superconducting accelerator and currently the highest-energy accelerator in the world. The cooling system, which brings supercold liquid helium to the superconducting magnets, is a crucial component of the Tevatron, and the landmark designation recognizes this significance.

When placed in service in 1983, the cryogenic cooling system was the largest low-temperature system ever built and had an important, two-pronged goal: to enable higher current in the magnets (providing higher energy acceleration) while at the same time reducing power consumption to one-third of what it would be at normal temperatures. This goal was successfully achieved.

In order to assure high reliability, the refrigeration system has two major components — the Central Helium Liquefier and a satellite refrigeration network located at 24 stations around the accelerator ring. Connected by an insulated pipeline atop the Tevatron berm, the cooling system delivers approximately 5,000 liters of liquid helium per hour to the magnets in the tunnel. The combination of a central facility with satellite refrigerators takes advantage of the higher efficiencies possible with large scale equipment and provides continued operation in the event of equipment failure.

The ASME landmark designation recognizes the decade of reliable operation as well as the innovative engineering involved in the initial design and fabrication of the system. Many innovations included in Fermilab's system have served as a model for similar systems around the world.

The ASME History and Heritage Recognition Program, which began in September 1971, provides a public service by examining, noting, recording and acknowledging achievements of particular significance. An ASME International Mechanical Engineering Landmark represents a progressive step in the evolution of mechanical engineering and reflects a positive influence on society worldwide.

(r) Fermilab Director John Peoples and Cherri Langenfeld, Director of DOE Chicago Operations, accept the ASME designation plaque on behalf of Fermilab and the U.S. Department of Energy. Fermilab is the 39th International Historic Mechanical Engineering Landmark designation since the start of the program in 1971.

At the ceremony, ASME National President John Fernandes presented a bronze plaque to Director John Peoples. In his acceptance speech, Dr. Peoples recognized the many and varied contributions of the Laboratory's engineering community to these successful, record-breaking accomplishments. ■

Lederman presented 1992 Enrico Fermi Award

At a recent private ceremony held in the Oval Office, President Clinton presented former Fermilab Director Leon Lederman with the 1992 Enrico Fermi Award. Sharing a second Fermi Award also presented by the president, were former Secretary of Defense and past Director of Lawrence Livermore National Laboratory Harold Brown and a former chairperson of the Defense Science Board at the Department of Defense and also past Director of LLNL John S. Foster, Jr.

Lederman is the second Fermilab director to win the award. Robert Rathbun Wilson received the award in 1984.

The Fermi Award is the government's oldest science and technology award and one of its most prestigious. It is given for a lifetime of achievement in the field of nuclear energy. This Presidential Award carries a gold medal and a $100,000 honorarium.

"Just over 50 years ago Fermi harnessed the atom," said Secretary of Energy Hazel O'Leary. "It is extremely fitting that these scientists be honored for continuing Fermi's tradition of selfless contribution to science." DOE administers the Fermi Award for the White House, and Secretary O'Leary presented the awards at a public ceremony in Washington, D.C. on July 29, 1993.

Lederman gave credit for the award to his association with Fermilab. "I think the award is mostly a recognition of the success of Fermilab—despite my 10 years as director," he joked.

Lederman's research has spanned four decades and includes some remarkable achievements, many of which were made here at Fermilab. These achievements include the discovery of the muon neutrino and his collaborative work in uncovering evidence for the bottom quark. In 1988 Lederman received the Nobel Prize in Physics for his muon neutrino research.

Beyond his work in experimental research, Lederman has long recognized the importance of science education, initiating over 15 educational programs for high school students and elementary school and college teachers while Fermilab director. His vision and leadership recently brought into existence the Illinois Mathematics and Science Academy and the Teachers' Academy of Mathematics and Science in Chicago. Fermilab's own Science Education Center bears Lederman's name.

Lederman continues to involve himself in educational projects and was recently chairperson of the XXIV International Physics Olympiad held July 10-18 in Williamsburg, VA. This is the first time the United States has been host of the event. He is also involved in educational projects with the Chicago Public Schools and continues to teach at nearby Illinois Institute of Technology. ■

President Clinton presented the 1992 Fermi Award to Leon Lederman, Fermilab Director Emeritus, shown with Secretary of Energy Hazel O'Leary and Mrs. Lederman at the recent ceremony in the Oval Office. (White House photo)

Rubinstein "knighted" by Consul General of France

At a ceremony held on June 24 at the residence of the Consul General of France in Chicago, Assistant Director Roy Rubinstein was among 11 Midwest educators and scientists to receive the *l'ordre des Palmes Academiques*.

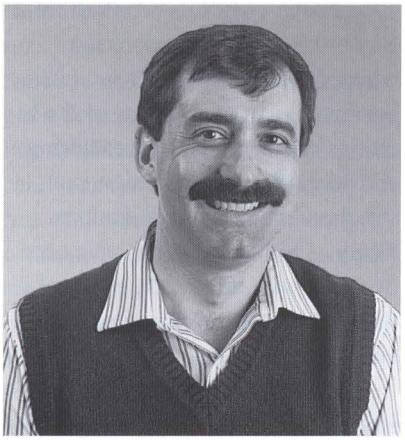
This French government award dates from the Napoleonic era and confers honorary titles upon individuals "for services to the French culture." Rubinstein received the title chevalier, or knight, and was decorated during the ceremony with an insignia and purple ribbon.

The decoration is conferred on professors, persons of letters, scholars and scientists who have distinguished themselves in the field of education and in the advancement of studies in the literary and artistic fields.

Nominations are made on the decision of the French Minister of National Education. ■

***Consul General Yves Gaudeul of France bestows upon Roy Rubinstein an insignia and purple ribbon signifying his new title* Chevalier dans l'ordre des Palmes Academic.**

Edward Kolb recognized by U of C undergrads



Edward W. Kolb, head of the Theoretical Astrophysics Department, was awarded the Llewellyn John and Harriet Manchester Quantrell Award for Excellence in Undergraduate Teaching from the University of Chicago.

Kolb was one of five teachers given the Quantrell Award at the university's convocation on June 12, 1993. Kolb was nominated for the award by University of Chicago undergraduate students. The convocation program called Kolb a "distinguished astrophysicist and committed teacher, with exuberant style. . .(who) has led his students on a wondrous journey through the universe from its infancy to the present and beyond."

Kolb has been a professor in the Department of Astronomy and Astrophysics, the Enrico Fermi Institute, and the College at the University of Chicago for 10 years. For the last five years he has been leading the undergraduate class "Cosmology for Poets."

"This is a well-known award at the university," said Kolb. "I've put in a lot of work. It makes me feel good to get recognized."

Kolb began working at Fermilab in 1983. He became head of the Theoretical Astrophysics Department the following year. ■

Appointments

Accelerator Division

Accelerator Division Head Stephen Holmes has made two recent appointments to fill the Accelerator Physics Department and Main Accelerator Department head positions.

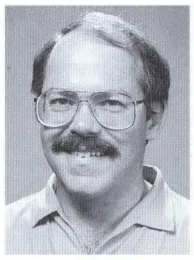
Patrick Colestock has been asked to head the Accelerator Physics Department, while John Marriner takes Colestock's previous position as head of the Main Accelerator Department. Steve Peggs left Accelerator Physics last year and the department has been headed by Francois Ostiguy in the interim. "I would like to express my deep appreciation for the fine job Francois has done...during this period," Holmes said.

Pat Colestock has been at Fermilab since 1990. He received his MSEE and Ph.D. from the University of Michigan. In 1976 he joined Rensselaer Polytechnic Institute at Oak Ridge National Laboratory where he developed ion beam-based plasma diagnostics for the Bumpy Torus experiment. In 1977 he joined the Princeton Plasma Physics Laboratory where he worked on experiments on the PLT and TFTR tokamaks, and participated in the design of the INTOR tokamak.

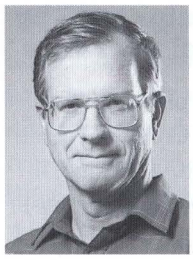
The Accelerator Physics Department head is responsible for managing and facilitating the theoretical and practical physics performance of the accelerator cascade. Colestock's goals for the Accelerator Physics Department include continued analytical and theoretical support of the accelerator's operation. He wants to focus on follow-up of current accelerator operation problems for the detector collaborations, and also continue to develop new projects and upgrades.

John Marriner came to Fermilab in 1974 as a graduate student. His thesis neutrino experiment was conducted in the 15 ft bubble chamber. Marriner later joined the Physics Department and worked on a Proton Center hyperon experiment. After moving to the Accelerator Division, he was involved in the TeV I project and commissioning of the Antiproton Source.

The Main Accelerator Department has overall responsibility for the Main Ring and the Tevatron systems. Working with the support groups and the Operations Group, the department ensures that the main accelerators are functioning at the highest possible level of performance.



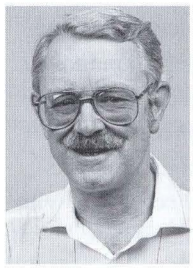
P. Colestock



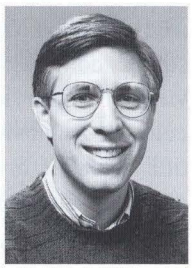
J. Marriner

K. Williams

D. Nevin



T. Murphy



D. Christian

Directorate

Kathy Williams has joined the Director's Office as manager of the Quality Assurance Office. She replaces Mark Bodnarczuk.

Williams will be responsible for the implementation of the Fermilab Quality Assurance Program. Williams graduated from Nasson College in Maine with a degree in Biology. She has 18 years of experience in both quality control and total quality management in the food processing industry. "Her experience will help us in the months ahead," said Associate Director Dennis Theriot.

Facilities Engineering Services Section

David Nevin has joined Fermilab as the deputy head of Facilities Engineering Services.

Nevin comes to Fermilab from Baxter Healthcare Corporation, where for 23 years he has held various management positions in site facilities engineering, manufacturing and specialized plant design, construction and start-up operations. Many of his assignments have been overseas with extended periods of time spent in Latin America, Europe and Asian operations.

He has worked in various construction-related disciplines including construction management, civil, structural and fire protection engineering.

Nevin has a wealth of experience in the current application of to-

tal quality management and customer service, having implemented these in the Facilities Engineering and Maintenance organization he led at Baxter's research and development campus in Round Lake, Illinois.

Research Division

Roger Dixon, head of the Research Division, recently appointed Thornton Murphy as head of the Research Facilities Department and David Christian as associate head of the department. They replace Greg Bock and Sam Childress.

In their new roles, Murphy has overall responsibility for the department and oversees its ES&H functions. He directly manages the activities of the Particle Detector Group, the Experiments Group and the Silicon Detector Group. Christian has responsibility for the department's budget and the Technical Support Group.

"The Research Facilities Department has been in a state of continuing change over the past years as it has struggled to accommodate the evolving style of high-energy-physics research," said Dixon. "Longer runs have meant longer times between runs. Colliders have brought giant detectors and collaborations into the field. One of Murphy's main challenges will be to redefine the role of the department so that it will continue to be useful to the researchers it supports."

Murphy came to Fermilab in 1973 after nine years at the University of Michigan and Carnegie-Mellon University. At Fermilab, he has been head of the Proton Area Department, associate head of the Tevatron Systems Department, leader of the RD Beams Group, head of the RD Cryogenics Department and associate head of the DØ Department of Installation. He also collaborates part time on several experiments. His major experiment at this time is E853, for which he is the spokesperson. "Although this experiment was motivated by an application to SSC, it has potential uses here at Fermilab as another way to extract beam to test beams, and, even without practical application, it is interesting accelerator science," said Murphy.

Christian joined Fermilab as a postdoc in 1982 after receiving his Ph.D. from the Johns Hopkins University. He was a Wilson Fellow and after joining the Fermilab staff served as assistant head of the Research Division Electrical Engineering Department. In this position, Christian helped establish a group with the capability of designing custom-integrated circuits.

His thesis experiment was a baryonium search done at SLAC using the LASS spectrometer. He collaborated on an experiment at Brookhaven that concentrated on the study of high multiplicity exclusive final states produced in np and pp interactions. As part of the same collaboration, he is now working on E690. This experiment, which took data in the 1990 Fixed-Target Run, will study the production of charmed particles in pp target diffractive dissociation. ■

Announcement

March 4, 1994, Fermilab will host the 80th Birthday Symposium in honor of Robert R. Wilson. For information E-mail Alvin Tollestrup, at DECNET: FNAL::ALVIN or Jean Lemke at DECNET:FNAL::LEMKE or call Jean at 708-840-3211. ■

Dates to remember

January 17-28, 1994
The U.S. Particle Accelerator School at the University of California at Los Angeles. Program of graduate level credit courses in beam physics and associated accelerator technologies. For information and application, contact the USPAS Office at Fermilab, MS 125, P.O. Box 500, Batavia, Illinois 60510-0500 or e-mail USPAS@FNAL or phone 708-840-3896

February 11-13, 1994
Physics Advisory Committee Meeting

April 8-10, 1994
Physics Advisory Committee Meeting

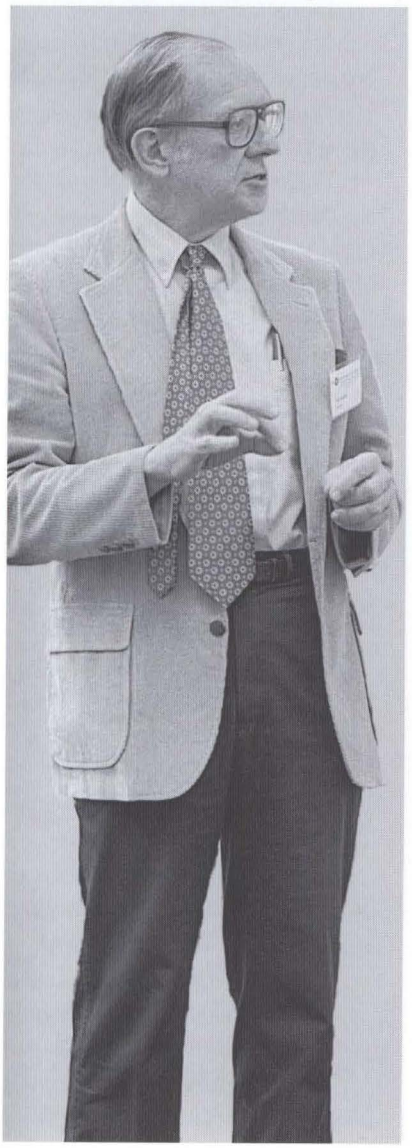
June 18-24, 1994
Physics Advisory Committee Meeting

June 29-July 14, 1994
Snowmass 94 - Particle and Nuclear Astrophysics and Cosmology in the Next Millennium, Snowmass, Colorado. Organized by the American Physical Society Division of Particles and Fields, Division of Astrophysics, and Division of Nuclear Physics; Roberto Peccei, UCLA, Chairman. Contact: C. M. Sazama, Fermilab, P. O. Box 500, Batavia, IL 60510-0500; Fax: 708-840-8589; E-mail: SAZAMA@FNALV

Events

FIA meeting sparks lively interchange

Change. Conversion. Evolution. Revolution. Reform. At the beginning of the 1990s, we hear these words in many contexts—when speaking about government, health care, education, science, to name a few. In science, the dramatic end of the Cold War has brought into even sharper focus the changes in the patterns of science research that have been gradually emerging over the last decade.



Fermilab Physicist Joseph Lach served as the chairperson of the recent FIA meeting that explored the role of science in the post-Cold War era.

The recent Fermilab Industrial Affiliates Meeting and Industry Briefing provided a forum for discussion of these changes in the scientific community. *Beyond the Cold War: The Changing Arena of Science* was the theme for the thirteenth annual gathering held at the Laboratory September 9 and 10. A record-breaking number registered to attend the meeting. They came from business and industry, from research laboratories and academia, from government and the media. Some participants were local; others traveled from California, Maryland, North Carolina and Minnesota.

All the attendees were treated to a lively, stimulating and thoughtful interchange on this relevant and timely subject. Although the meeting's four speakers represented different perspectives and came from different backgrounds, there was a surprising degree of consensus in their comments and conclusions.

The first presenter, Roald Sagdeev, previously director of the Institute for Space Research in the former Soviet Union and currently a professor of physics at the University of Maryland, spoke with wonder about the huge amplitude of change in science research, commenting, "We have changed the paradigm. The scale of change is tremendous." Sagdeev succinctly summarized the post-Cold War world saying, "The United States has nobody to defend itself against. Russia has nothing to defend."

Richard Slansky, leader of the Theoretical Division at Los Alamos National Laboratory, picked up this last theme noting, "We're all having problems—not just the former Soviet Union!" He used words such as "scary" to depict the current world scene stating, "There is no reason to worry about full-scale nuclear war. There is every reason to worry about one bomb going off." Reflecting on his professional life, Slansky noted that he himself is an example of the many scientists who have, for years, operated in two realms—"the world of discovery and the world of national defense." Then looking to the future, he pointed to the urgent need to craft new kinds of relationships between the national labs, industry and academia and advocated a "renegotiation of the social contract" between scientists and the public. Finally, Slansky called for people "all along the bridge" to take us from basic research to practical applications.

Leon Lederman, Fermilab's Director Emeritus, the banquet speaker for the meeting, also looked both to the past and to the future. He, too, identified the same three arenas— science and industry, the universities and the government through the national labs. "The success of the period of 1950-1980 came from a healthy balance of competition and collaboration between these elements," he continued.

Lederman then detailed some of the problems that the 1990s have brought to these three arenas: industry "constrained to find short-term paychecks for CEOs-in-a-hurry;" universities dealing with precarious funding and "the increased cost of meeting regulatory obligations;" national labs coping with limited budgets and, particularly the weapons

"We're all having problems—not just the former Soviet Union!" said Richard Slansky, leader of the Theoretical Division at Los Alamos National Laboratory.

labs, needing to redefine themselves. The cloud, which hovers over all these arenas, according to Lederman, is "the failed education system, which graduated fewer and fewer students in the fields of science and technology."

After painting this somewhat gloomy picture of the state of science in the 1990s, Lederman issued a call for renewal and rededication saying, "It takes more than science and more than clever engineering to meet the challenges of today. It takes determination, vision, will, courage and leadership" to address the current situation. Closing on an optimistic note, Lederman maintained, "Scientists offer hope for the future."

The next morning, Lewis Franklin, formerly of TRW's Space and Defense Sector and currently a visiting scholar at the Stanford Center for International Security and Arms Control, addressed the Affiliates meeting from the perspective of industry.

He spoke about greenfielding— a new model of renewal whereby the old, unsafe, outmoded factory or laboratory is simply abandoned and a fresh, new venture started on a so-called green field. In an effort to accommodate dwindling defense-based research, Franklin suggested that, "We should subcontract out corners of our national laboratories. We should bring companies inside our gates."

The last portion of the two-day meeting was devoted to a panel discussion facilitated by Joseph Lach of the Research Division and the meeting's chairperson. With questions, solutions, comments and quips all being exchanged, this session offered an opportunity for animated dialog between the speakers and the audience.

A number of difficult questions were raised:

- What is the price of the peace dividend?
- Where will incremental job growth come from in the next 20 years?
- What is the degree of cohesiveness of the national lab system?
- How can small businesses "get a part of the action?"

A number of suggestions were also offered:

- Sagdeev noted that we need to decentralize and deal with a diversity of problems.
- Slansky called for assistance in cutting bureaucracy and an overhaul of the Cooperative Research and Development Agreement (CRADA) process.
- Many speakers, both on the panel and in the audience, called for new and more effective ways to communicate with the public in order to proclaim and to explain the limitations as well as the possibilities of scientific research.

The Industrial Affiliates Meeting itself was an example of this kind of communication. Fermilab's Office of Research and Technology Applications, headed by John Venard, sponsored the meeting.

The Fermilab Industrial Affiliates organization was founded in 1980 to improve communications between industry and Fermilab and its user-university community, and to facilitate the spin-off of state-of-the-art developments from the Laboratory.

The Affiliates are a group of about twenty-five organizations, each of which has an interest in the research and development work underway at the Laboratory. ■

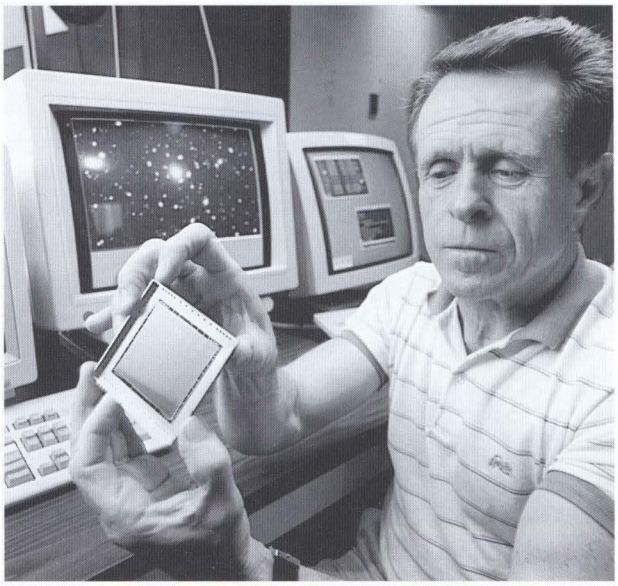
Fermilab astrophysicists conduct "first run"

The Computing Division's Experimental Astrophysics group embarked on Fermilab's first-ever Experimental Astrophysics run August 12. The run marked the group's first use of a new charge coupled device (CCD) camera, the drift scan camera. This camera is designed to take astronomical images and store them for later viewing. This CCD technology now makes remote observation of the stars possible.

The purpose of this run was to test the operation of the drift scan camera that eventually will be placed on a 3.5-meter telescope at Apache Point, New Mexico, where the Sloan Digital Sky Survey telescope will be. Members of the Experimental Astrophysics group also hope to observe some interesting astronomical phenomena while conducting the nightly tests outside Lab 7.

Tim McKay, Lederman Fellow in the Physics Section and one of the key operators of the drift scan camera system, said the real virtue of doing this test run "is not so much looking at the sky as it is testing the camera in something like the real mode." McKay said that through the test, which ran about two weeks, the group discovered "all kinds of things about the user interface, starting the system up, stopping it and making it run in an actual experimental setting." McKay added that the group has learned a lot about how they want to operate the camera at an observatory. "It's great to do that here instead of at a $10,000 a night telescope. Even just moving it once is a big test. But every time we do the test it gets significantly better. We have proven we can drift scan without any significant image problems."

Bryan MacKinnon of the On-line Support Department said the camera is analogous to photographic film. The CCD is mounted in a dewar, or cryogenic tank. As light passes through the telescope to the CCD, image data is read from the CCD. It is monitored in real-time on a display and eventually recorded on disk and tape.



Electrical Engineer Merle Haldeman displays a charged coupled device used in the drift scan camera. This technology replaces the role of the human eye in a telescope. The CCD captures an image and converts it into data that can be used to reconstruct an event in locations remote from the telescope. This means that a scientist located thousands of miles from the telescope can observe the sky as the data is collected from a screen on his or her desk.

The concept of drift scanning, however, is slightly different from that of a regular video camera. "The idea of drift scanning," said McKay, "is you can point your telescope at the sky and not move the telescope. What we do in the drift scan camera is instead of rolling film, we move the image across the CCD chip at the same rate as the sky goes by. Consequently, we get a picture of a long strip of the sky."

The original idea for the camera came through the collaborative efforts of three experimental astrophysicists, Rich Kron, Steve Kent and Chris Stoughton. Since then, the project has grown to encompass four different groups at Fermilab and nearly 30 people. Besides the Experimental Astrophysics group involvement, others who played key roles in the development of the camera include the Computing Division's On-line Support Department, under the guidance of Associate Head Don Petravick and the Research Division's Detector Electronic Systems group, led by the efforts of Ray Yarema and Merle Haldeman. The On-line Support Group designed, developed and integrated the camera's computer system, including a custom VME board. The Detector Electronic Systems Group designed and developed the front-end electronics that take the light gathered by the telescope optics and convert it to digital data. The data is then processed by the On-line Support Group for various types of

image reconstruction. The Physics Section, through the efforts of Hans Jöstlein and others, assisted with the logistics of the project, providing the space for the telescope and camera in Lab 7.

The camera will be moved to Apache Point after the 3.5 meter telescope is complete. The Experimental Astrophysics Group expects it to be finished in October. At Apache Point the group plans to conduct several experiments with their camera, probing such questions as the isotropy and expansion rate of the universe. ■

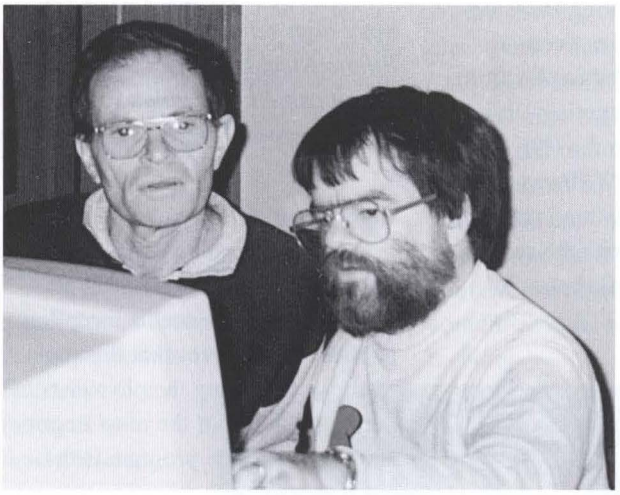
B physics conference explores the use of hadron accelerators

A workshop jointly sponsored by Fermilab and the SSC Laboratory convened this summer in Snowmass, Colorado. The *Workshop on B Physics at Hadron Accelerators*, which met from June 21 through July 2, brought more than 200 members of the high-energy-physics community together in a cooperative effort.

The principle goal of the workshop was to explore the opportunities for the study of *B* physics, especially CP Violation, at hadron accelerators and to lay the foundation for proposals for new detectors or upgrades of existing ones. There have been four short workshops on this subject over the past year at Fermilab and the SSCL, but these were all preliminary to the major two-week study.

Both the theoretical and experimental aspects of beauty physics were explored in detail, with the goal being to develop a coherent long-term program. The specific efforts of the workshop included defining physics goals for *B* physics research, setting performance specifications, studying technological choices and layouts, and examining background conditions.

The first day of the workshop was devoted to talks by invited speakers summarizing the status of *B* physics. There were several other invited and contributed talks throughout the workshop. Invited speakers from Fermilab included Jeff Spalding (Research Division), Isi Dunietz (Research Division/Theoretical Physics) and Shekhar Mishra (Accelerator Division).



Physicist David Ritchie (r) of the Fermilab Computing Division assists a colleague with computing needs during the B physics conference.

The members of the workshop were primarily concerned with a detailed, quantitative comparison of 14 current or proposed experiments for *B* physics. They met in small groups on specific topics of interest. These working groups were convened by physicists from all over the world. Fermilab conveners included Vinod Bharadwaj (Accelerator Division), Pat Colestock (Accelerator Division) and Fritz DeJongh (Physics Section).

The comparisons of different experiments will not be developed into specific proposals until the group members and their conveners have compiled the work done during the workshop. Reports on the work will appear in the proceedings that will come out this fall.

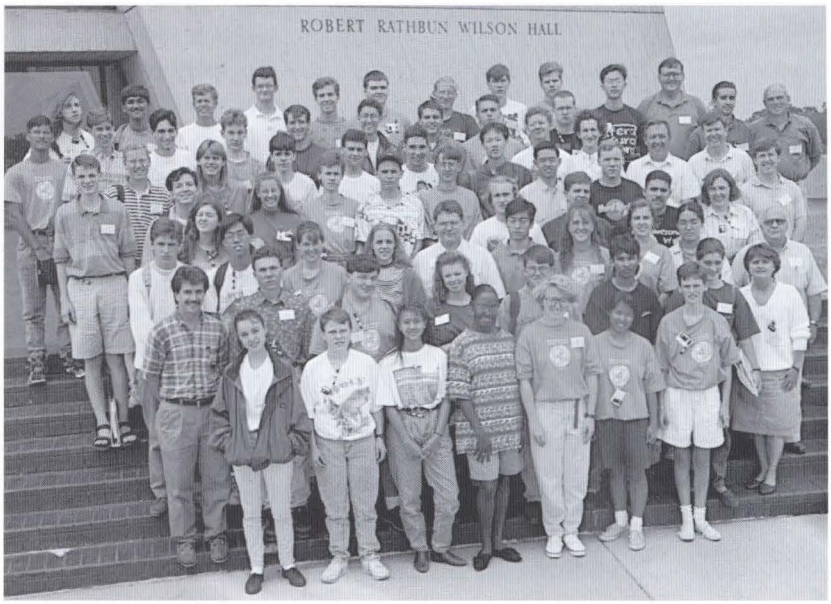
In general, however, the Fermilab collider capability is thought to compare favorably with other experiments or proposals. Because the Tevatron is the highest-energy collider in the world, it can effectively produce greater numbers of *B* decays than any other project. Fermilab physicist Shekhar Mishra, one of the organizing committee members, explained that Fermilab's collider can produce orders of magnitude more *B* decays than the proposed "*B* Factories" at SLAC, Cornell or KEK could produce.

Mishra was one of several Fermilab staff to serve on the organizing committee for the workshop. The others were Ron Lipton (Research Division), Isi Dunietz, Cynthia Sazama (Physics Section), and Jeff Appel (head of Physics Section), who was co-chairperson of the workshop along with Vera Lüth from SSCL.

The workshop was kept running smoothly by a dedicated office

staff and computing service. Cynthia Sazama, of the organizing committee, and Suzanne Weber (Physics Section), along with colleagues from SSCL, kept the registration, mail and daily operations of the workshop on schedule.

The computing staff, headed by Dane Skow (Physics Section), put forth an outstanding effort to keep workshop members connected with home, but more importantly keep them connected with the high-energy-physics computer processing power around the world. Peter Cooper (Physics Section), Vyto Grigaliunas (Computing Division), Andy Lego (Computing Division), Karen Carew (Physics Section), Candies Kastner (Physics Section), David Ritchie (Computing Division), Marcia Streetman (Physics Section) and Craig Williams (Physics Section) were all "on loan" from Fermilab to assist with the computing needs of the workshop. ■



Sixty high school students representing all of our nation's 50 states, Puerto Rico, British Columbia, Australia, Italy, Germany, Mexico and Japan came to Fermilab to work with scientists as part of the U.S. Department of Energy's Honors Students Program.

DOE Honors Students explore science in the real world

Sixty of the nation and world's most promising young students converged on Fermilab June 19 for the 1993 DOE Honors Students program.

For two weeks these students from all fifty states, Puerto Rico, British Columbia and several other foreign countries including Australia, Italy, Germany, Mexico and Japan got to see high-energy physics research from the scientist's point of view. Daily lectures and hands-on demonstrations, working to build actual experimental equipment and completing detailed reports, and social interaction with a group of peers were all part of the experience.

Drasko Jovanovic has been the driving force behind the program here at Fermilab since its inception in 1987. He believes that this program is developing the physicists of the future. "One of the most important aspects of the program is the close contact with scientists throughout the two weeks and well after the program," he said. Jovanovic can easily back this up—he has written many recommendation letters to undergraduate and graduate schools for past students, and has seen two receive their Ph.D.'s.

A positive addition to the honors students program has been the outstanding work of Bob Grimm, a high school physics teacher on sabbatical and working with the Education Office this year. "Bob has pretty much organized the whole thing," said Jovanovic. "He's made my life a lot easier."

Grimm's philosophy for the two-week program was one of providing excitement, information and not a dull moment. "The collection of this much 'grey matter' in one place and time is so rare, we don't want to waste an instant of it," said Grimm. Keeping so many highly motivated and enthusiastic young people occupied proved to be a pleasant challenge for Grimm.

In the mornings the students attended lectures on high-energy physics and particle detection. These morning lectures are based on Fermilab's popular Saturday Morning Physics series, and are supplemented by informative "gee-whiz" demonstrations and lectures by area high school teachers. These 10 teachers also acted as advisors and supervisors for the students. "The increased number of dedicated and high-caliber teachers we had this year has really made a difference,"

said Kristin Ciesemier, Education Office program leader.

The afternoons were filled with tours of various areas of Fermilab and with the students' hands-on projects for the program. Students constructed and tested photomultiplier bases and scintillators that will eventually be used in real research here at the Lab. "That's one of the best experiences they can have," said teacher Jim Hicks. "They not only get a sense of ownership, but they also realize that they're actually contributing to particle research."

Outside of this daily routine, the young scientists did some real interactive research, "studying" the physics of amusement parks at Six Flags Great America, and the physics of wave pools at Magic Waters. Don't be fooled—they were all there *strictly* for scientific purposes. The students also visited downtown Chicago.

The 60 honors students, who were housed in dormitories at nearby Wheaton College, had much to say about their Fermilab experience.

"It's been a great experience," said New Jersey native Owen Faris, "I like being able to talk with the scientists and ask questions."

"Drasko is really great," said Kimi Ishibashi, a student from Nevada. "He usually comes around every day and asks us how the lectures were, how things went or if we have any other questions."

The young people filled in their off-time with card games, a volleyball tournament, movies and a lot of conversation (some heavily intellectual, some typically teenage). "Its really nice," Kimi said, "because a lot of my friends back home don't know what I'm talking about when I start a discussion. . .here everybody is kind of up to the same level."

Armondo Torres, a student from Delaware, felt an appreciation for the variety of personalities. "The thing that made a big impact is that you get to see what kind of people are interested in physics." Many students expressed surprise at having the stereotype of the scientist dispelled.

That may be the most important lesson of all for these students. As Grimm said, "They realize that all these people [Fermilab researchers] at one time or another have put together photomultiplier bases or crawled into spaces not designed to be crawled into. That's how science is done, it isn't all glory or theory. It is hard, sometimes menial work, but you struggle and suffer and eventually it works." ■

UEC elects new leaders

The Fermilab Users Organization recently elected its 1993-1994 Users Executive Committee. The newly elected members are Amber Boehlein, Texas A&M University; Nicholas Hadley, University of Maryland; Thornton Murphy, Fermilab; Heidi Schellman, Northwestern University; Pekka Sinervo, University of Toronto and Philip Yager, University of California, Davis. They will each serve a two-year term.

The new members join continuing members Bruce Barnett, Johns Hopkins University; Myron Campbell, University of Michigan; John Cumalat, University of Colorado; H. Eugene Fisk, Fermilab; Catherine James, Fermilab and Sally Seidel, University of New Mexico. Past Chairperson David Cutts, Brown University, is serving a third year to ensure a smooth transition for the new members.

The UEC will hold its fall meeting on October 14 at Fermilab. At this meeting, the committee will elect a new chairperson.

The Fermilab Users Organization was first organized in 1967 "to provide a forum for discussion of scientific and administrative matters relevant to the organization and construction of the Laboratory." The organization elected its first executive committee at its second general meeting.

The new UEC is (standing, l to r): Amber Boehnlein, Thornton Murphy, David Cutts, Nicholas Hadley, Pekka Sinervo and Heidi Schellman. (Sitting, l to r): Myron Campbell, Bruce Barnett, Catherine James, John Cumalat and Philip Yager. (Not pictured) Eugene Fisk and Sally Seidel.

The UEC was formed to carry out organization business between general meetings and to represent the interests of the entire Fermilab high-energy-physics community. During the early years of the Laboratory, the UEC initially devoted a great deal of its time to addressing the physical needs of the users which included housing, safety and procedural concerns. The UEC is still concerned with issues such as user transportation, office space and computing services, but a major concern at the moment is the recent budget constraints that have become a central issue in the future of high-energy physics. This issue was addressed during a panel discussion, moderated by UEC Chairperson David Cutts, that concluded the Annual Users Meeting in June.

The committee has always been concerned with the public's perception of Fermilab research and the research community. However, the UEC believes that the current need to inform the public about the importance of the Laboratory to the scientific community has never been greater.

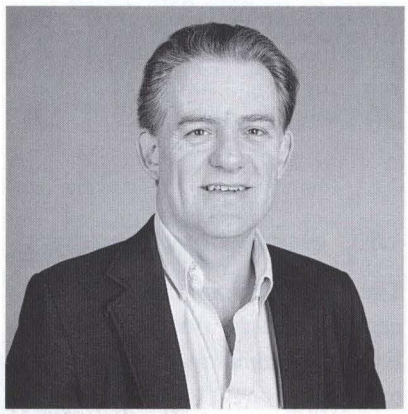
The long-term goals of high-energy physics depend upon continuing the current traditions of basic research and strong technical advancement. In order for physicists to be prepared for the next generation of accelerators they must learn and develop at today's accelerators. "We must have a present in order to have a future," said UEC Secretary George Ginther.

While the focus of the Fermilab Users Organization is changing with time, its commitment to the researchers and students who "use" the Laboratory has remained constant. Its membership is open to anyone with a professional interest in the research program at Fermilab. For further information regarding membership in this organization, contact the Fermilab Users Office at MS 103, 708-840-3111 or USERSOFFICE@FNAL. ■

Brown returns from NSF service

Fermilab physicist Charles Brown recently returned from our nation's capitol where he served for over a year as a guest program officer for the National Science Foundation's Physics Section.

As a program officer, it was



Brown's job to review and recommend funding for proposals to NSF's elementary particle physics program. NSF funds account for about one-third of all federal funding of university-based research in the field of high-energy physics and cosmic-ray physics. The remaining two-thirds is funded through the U.S. Department of Energy.

Now back at Fermilab, Brown says the experience was an exceptional one for him. "Its really gave me a chance to learn a lot of physics outside of what we do here at Fermilab," he said. "It was a true sabbatical in the sense that I was able to see and learn physics from a different perspective."

The NSF tries to keep about half of its 200 program officers as rotating, or guest, scientists. This ensures a continually fresh, up-to-date and scientifically experienced staff. Guest program officers usually come from educational institutes, national laboratories or private industry. Along with full-time staff, they solicit anonymous peer reviews and make recommendations on funding requests for research in most areas of science, engineering and science education.

Program officers are responsible for understanding and reviewing the proposals for research in a particular field (such as high-energy physics). They typically contact six other scientists, who have expertise relevant to the proposal, and ask them to make anonymous reviews of the request. The program officer's recommendation is then based on these reviews, as well as information obtained at laboratory research program committee meetings, previous results presented to scientific conferences, and on the funds appropriated to the individual program.

Program officers also play a key role in the yearly request to Congress for funds, outlining and justifying the funds needed for their program.

The NSF review process is very stringent and relies on the unbiased nature of review. A big concern for Brown and the NSF was conflict of interest. "They worry a lot about conflict of interest [at NSF]," said Brown. "They work very hard at reviewing in an honest and complete way." To minimize conflict, Brown handled few Fermilab-related proposals while at the NSF.

This is the first time that someone from Fermilab has taken a leave of absence to work for the NSF in this review process. Brown says that he received great support from the Laboratory in breaking this new ground.

Although no Fermilab physicist had worked previously at NSF, several have had similar positions in the past for DOE in its review process. Richard Carrigan (Directorate) is currently on leave from the Laboratory to fill a similar visiting high-energy-physics position with the Department of Energy.

"Dick and I and the many other scientists who help the funding agencies in Washington play an important role in continuing the self-policing peer review system that has helped create the most productive science climate in the world. We hope other scientists consider such a sabbatical year," said Brown. ■

Recognition

Fermilab plays significant role in the education of new physicists

In 1992-1993 over 70 physicists received Ph.D.'s from their home institutions for research done in experimental collaborations at Fermilab. There are, on average, between 400-500 graduate students and 80-100 post-doctorates working at Fermilab at any one time. In a field where active researchers number only a few thousand across the entire globe, this is a significant portion of the young scientists in the high-energy-physics community.

The recipients include:

- Eric Matthew Aitala, University of Mississippi, E791
- Nural Akchurin, University of Iowa, E704
- Gilvan Augusto Alves, Centro Brasileiro de Pesquisas Fisica, E769
- Sandra F. Amato, Centro Brasileiro de Pesquisas Fisica, E769
- Richard Astur, Michigan State University, E740
- Mark Baker, Massachusetts Institute of Technology, E665
- Jeffrey W. Bantley, Northwestern University, E740
- Gavin Blackett, University of Tennessee, E687
- Valeria Bolognesi, University of Pisa, E741
- David S. Brown, Michigan State University, E706
- Dong Chen, State University of New York, E761
- William Cobau, Michigan State University, E733
- Janet Conrad, Harvard University, E665
- Raymond Culbertson, University of Illinois, E687
- Chris L. Darling, Yale University, E769
- Carlo Dallapiccola, University of Colorado, E687
- Tim Dubbs, University of Iowa, E761
- Sarah Durston, University of New York at Rochester, E740
- James Fast, University of California at Irvine, E760
- Maurice Foucher, Yale University, E761
- Elizabeth Gallas, Michigan State University, E733
- Therece Geld, University of Michigan, E740
- Dave Gerdes, University of Chicago, E741
- Keith Gollwitzer, University of California at Irvine, E760
- Detlev Hantke, Munich, E665
- John Hissong, Yale University, E755
- Terry Heuring, SUNY at Stony Brook, E740
- B. Todd Huffman, Purdue University, E741
- Rick Jesik, University of Illinois at Chicago, E672
- Loius Joseph Keeble, Texas A&M University, E741

Continued on page 28

- Christopher J. Kennedy, University of Notre Dame, E687
- Robert Kennedy, University of California San Diego, E665
- Jonathon Kotcher, New York University, E740
- Mathew S. Kowitt, University of California Berkeley, E789
- Mary Lauko, Rutgers University, E632
- Thomas Joseph LeCompte, Northwestern University, E705
- Rui Li, Indiana University, E672
- Roberto Mahon, University Sao Paulo, Brazil, E761
- Anna Majewska, Pennsylvania State University, E760
- Greg Makoff, University of Chicago, E731
- Sandra Malvezzi, University of Milano, E687
- Richard Markeloff, University of Madison, E741
- Jose Marques, University of California at Irvine, E760
- Mara Martini, University of Ferrara, E760
- João Ramos Torres de Mello, Centro Brasileiro de Pesquisas Fisica, E769
- Andrew Milder, University of Arizona, E740
- Jussaro Marquesde Mirando, Centro Brasileiro de Pesquisas Fisica, E769
- Antonio Morelos-Pineda, CINVESTAV, Mexico, E761
- Steve Moulding, Brandeis University, E741
- Raymond J. Mountain, University of Notre Dame, E687
- Donna Naples, University of Maryland, E683
- Chau Nguyen, Rice University, E704
- Etsuko Niu, Toho University, E653
- Satoru Ogawa, University of Tsukuba, E741
- Bo Pi, Michigan State University, E740
- Danilo L. Puéseljíc, University of Notre Dame, E687
- John Reid, Pennsylvania University, E760
- Todd Satogata, Northwestern University, Accelerator Physics Program
- Qifeng Shen, Duke University, E705
- Stephen F. Takach, Yale University, E769
- Yao Tan, Northwestern University, E705
- Rick Tesarek, Duke University, E705
- Steve Vejcik, The Johns Hopkins University, E775
- Dhammika Weerasundara, University of Pittsburgh, E706
- Judd O'Hara Wilcox, University of California at Davis, E653
- Stephane Willocq, Tufts University, E632
- Jaehoon Yu, State University of New York at Stony Brook, E740
- Manuel E. Zanabria, University of Notre Dame, E687
- Yinghao Zhan, University of Notre Dame, E765
- Chong Zhang, Carnegie-Mellon University, E653
- Jack Zhao, Northwestern University, E760
- Qiuan Zhu, Rice University, E683

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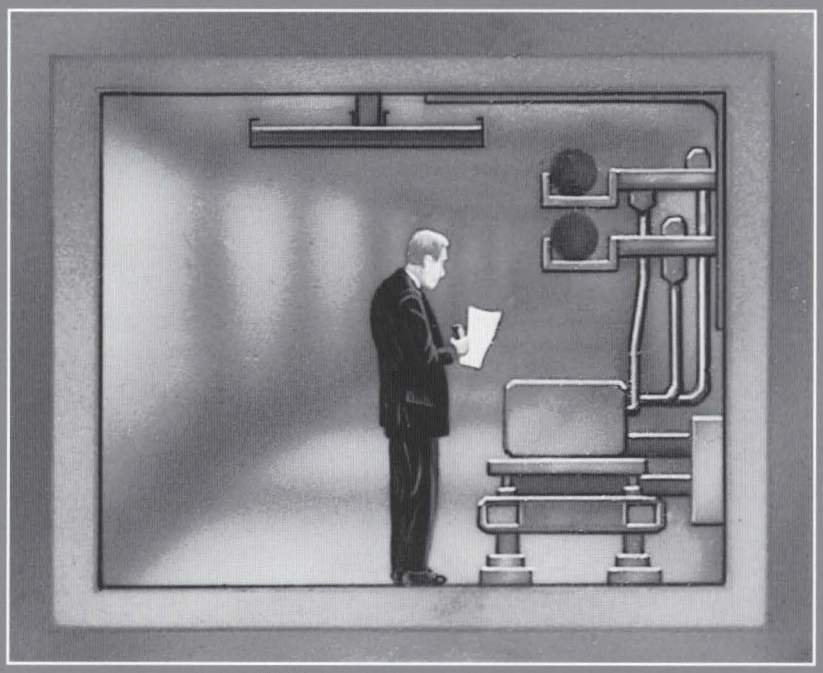
Cover photographs: (front) Wilson Hall, the Laboratory's administrative building, looms above the Fermilab reconstructed prairie. Nestled in the woods is the Leon Lederman Science Education Center—a resource dedicated to the enhancement of precollege science education. (back) An artist's rendering of the Fermilab Main Injector tunnel. The Main Injector will increase the number of proton-antiproton collisions in the Tevatron. Physicists expect that this enormous enhancement will make it possible for them to discover and study the top quark and to test important theoretical concepts concerning the origin of matter and the universe.



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