FermiNews

Fermi National Accelerator Laboratory

Volume 21 | Friday, April 17, 1998 | Number 8

Photo by Reidar Hahn

Fermilab Director John Peoples (right) confers with Department of Energy reviewer Andrew Mravca during the Lab's three-day annual review.

INSIDE

Peoples Makes Fermilab's Case at Annual DOE Review

Director shares struggle to balance present commitments and high-energy future.

By Mike Perricone, Office of Public Affairs

Fermilab Director John Peoples told a panel of DOE reviewers and outside experts that preparations for Collider Run II at the Tevatron were consuming most of the Laboratory's resources, leaving little room for work on anything else, including the future of the field.

"We face a difficult choice between superb science now and having a lab with a future," he said.

The wood-paneled room was still, with overhead slides contrasting budget figures with scientific goals. On this second day of the Lab's three-day annual review held March 31–April 2, Peoples' message never deviated, painstakingly addressing the Lab's conundrum over simultaneously pursuing present opportunities while confronting the future at current budget levels. Without histrionics—and without beard, cigar or olive-drab fatigues—Peoples nonetheless offered a convincing approximation of a noted Cuban orator.

"This is my Fidel Castro speech," he said, pausing for breath during his 2-hour, 20-minute presentation.

continued on page 2

Peoples

continued from page 1

The date was April 1, but Peoples' self-comparison to Castro was one of his few stabs at humor. He focused repeatedly on the dilemmas presented by the Lab's commitment to three unyielding priorities:

- Run II at the Tevatron, with its new Main Injector and upgraded detectors;
- contributions to the Large Hadron Collider (LHC) and CMS detector at CERN, the European particle accelerator laboratory;
- planning for a strong U.S. future in particle physics after LHC supplants Fermilab at the frontier of high-energy physics research some time around 2006.

"The Lab can't do everything at once," he said. "Everything is going into Run II, and I don't think we can fit any more in without damaging the long-term future of the Lab."

Peoples referred continually (and pointedly) to the Guiding Principles presented by the Gilman Subpanel on Planning for the Future of U.S. High Energy Physics, a task force formed by DOE's influential High Energy Physics Advisory Panel (HEPAP).

The subpanel, chaired by Fred Gilman, professor of physics at Carnegie Mellon University, recommended efforts to "maximize the potential for major discoveries by making best use of existing U.S. facilities and participating in unique facilities abroad; to position the U.S. for a long-term leading role at the energy frontier; and to prepare the next generation of scientists."

The message from Peoples: the Lab is indeed making all those efforts, and is being stretched to painful thinness by budget and personnel constraints.

" We face a difficult choice between superb science now and having a lab with a future."

John Peoples,
Fermilab Director

"Even the highest priorities are not affordable within the confines of our current budget," the director said, pointing to a projected \$6-million shortfall for FY1999 and a gap approaching \$30 million for FY2000. He added that a tight employment market exacerbated the problems of a tight Lab budget, allowing engineers, physicists and software professionals to vote with their feet for higher paychecks in private industry.

"It's the first time I've ever seen physicists able to go to outside industry and raise their salaries by 80 percent," he said.

Peoples emphasized that the Tevatron, with Run II scheduled to begin in 2000, is the only U.S. facility on the energy frontier with the prospect of major discoveries. As for "unique" facilities, in the U.S. or abroad, Peoples declared: "We're working on FOUR of them: the Tevatron, LHC, the 4TeV-center-of-mass muon collider, and VLHC."

The muon collider and Very Large Hadron Collider (VLHC) are under study for the post-LHC era at Fermilab—but Peoples said unforeseen problems (such as repairs to Wilson Hall and to the low-conductivity water system of the Main Injector) go to the front of the line for money in a tight budget.

"Getting ready for Run II is our highest priority, and it is an overwhelming priority," he said. "Preparations for Run II account for 72 percent of our budget, or \$161 million in FY1998. Our second-biggest item is LHC at 5.5 percent, and most of that involves LHC-specific funding."

Peoples said he would offer only limited commitments to a possible Run III, until after Run II begins. He intends to step down in 1999, and he made it clear that any further Run III commitments should come from the next director. He also concisely portrayed the Run III dilemma.

"Run III would be superb until LHC is in operation, then it's immediately obsolete," he said. "We're driving a car at 80 miles an hour and we have a cliff in front of us called LHC. You don't speed up to 100 miles an hour and then put on the brakes five feet away from the cliff."

Admitting that accelerator research and development "has never gone over very well at Fermilab, and I'm not proud of that," Peoples said he hoped to see more money directed that way after 1998. But he reminded the reviewers that a commitment to the future is only as sound as its funding, as illustrated by the experience of the Lab's first director, Robert Wilson.

"Bob Wilson proposed superconductivity to double the energy of the Main Ring, and by 1979 it represented 38 percent of the budget," Peoples said. "That's the scale of the effort we need." ■

The director reinforces a point being made during one of the Lab's presentations to DOE reviewers.

Photo by Reidar Hahn

Annual Review:

Lab Focused on Run II

New accelerators, new detectors, new computing—and then there's the future.

By Mike Perricone, Office of Public Affairs

Three days of presentations to reviewers from the Department of Energy left no doubt about the intensity of Fermilab's focus on preparations for Run II.

There was also little room for doubt that the Lab will need more resources to finish the job while continuing to plan for the future.

John Cooper, head of the Particle Physics Division, said work on upgrading the CDF and DZero detectors "consumes" his division.

"Of 561 people in our division, 368 are directly involved in building the CDF and DZero upgrades," Cooper told the review panel. "We'll have to hire 30 to 40 term employees to get the detectors ready."

Fermilab Director John Peoples said Run II could begin with a single detector, if necessary.

Keith Ellis, head of the Theoretical Physics Group, outlined plans for a series of workshops on "The Physics of Run II." The content of the workshops will follow what he called "the yellow book road," leading to a published document. The companion Web site for the workshops is what Ellis called a "field of dreams": "Build a Web page, and they will come," he said.

Director Peoples supported a limited astrophysics program at the Lab, calling it "a small part of our program but an important part." Astrophysics accounts for about 1.5 percent of the Lab's budget.

Run II will make a huge demand on data-taking and information storage capabilities. Ruth Pordes of the Computing Division said estimates by the Data Access Management Needs Assessment Group are running near one terabyte per day per experiment. The Computing Division has combined with CDF and DZero in mounting Joint Offline Projects for Run II, with 54 of the division's 105 computer professionals assigned to data and software strategy.

continued on page 4

Speakers at the Review discussed the difficulty of planning for future experiments with Fermilab strongly focused on Run II. Here, physicist Joel Butler surveys the construction site for BTeV, the proposed *B* physics experiment, which has been approved as a research and development project but not yet as a full experiment. "It's braver and more aggressive than the competition," Butler said. "We have lower energy, and we have to work harder."

Deputy Director Ken Stanfield said the Lab's staffing level has gone from 2,400 in 1991 to 2,030 in 1998. "We've overdone it," Stanfield said of the drop.

Photos by Reidar Hahn

Looking ahead to Run II, Accelerator Project Manager John Marriner worried that "we won't have enough physicists to have all four machines running three shifts for seven days a week."

Annual Review

continued from page 3

"Physicists probably spend one-third of their time on software development, while Computer Division professionals will spend 70 to 80 percent of their time," Pordes said. "The demands on software are much greater because of new detectors, new hardware and the long life of experiments, lasting 10 years or more."

The Lab is leading the U.S. effort in supplying magnets for the Large Hadron Collider at CERN. The first of four short test magnets is "basically done," with two others under construction, said Jim Kerby, program manager for the Lab's locally-directed LHC effort.

"We're planning for a review in October," Kerby said. "These are the first superconducting magnets built here in five years."

Fermilab has also been asked to assume the management of the U.S. portion of the CMS detector project for LHC.

"This is a very important role Fermilab is playing, and it's not well known outside the CMS community," said DOE reviewer John O'Fallon.

But Steve Holmes, Head of Beams Division, might have spoken for the entire Lab when he said his division was focused almost completely on Run II, and would plan for the future at whatever level it could afford. He concluded that the Lab could not overlook its "unique position."

"We're the only facility in the world that can make discoveries reshaping our understanding of the physical world in the next decade," Holmes said. "Our real challenge is to capitalize on that opportunity." ■

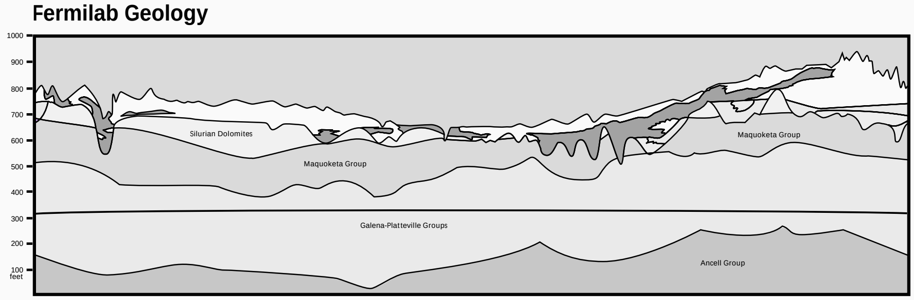
Fermilab's Joe Incandela (left) explains chip production to DOE reviewer Philip Debenham at the Silicon Detector Facility. "Ninety percent of what we do is for Run II," Incandela said. Looking on is Harry Melanson.

Photos by Reidar Hahn

Butch Bianchi, Cosmore Sylvester, Dean Validis and Peter Mazur with a prototype low-field magnet developed for a VLHC (Very Large Hadron Collider). Fermilab is conducting magnet research and development to seek the capability for higher energy at lower cost than current methods allow.

The geology of the Fermilab region promotes low-cost tunneling. Advances in tunneling technology are lowering costs.

Fermilab Geology



New Support for Muon Collider R&D

by Sharon Butler, Office of Public Affairs

Just last February, as part of efforts to "position the U.S. for a long-term leading role at the energy frontier," the Gilman Subpanel on Planning for the Future of U.S. High Energy Physics recommended expanding research and development on a possible future muon collider.

And already rolling is the muon collider collaboration of which Fermilab is a part—thanks to more than $1 million in new funding from the U.S. Department of Energy.

A dozen Fermilab physicists, as well as scientists from Brookhaven National Laboratory, Lawrence Berkeley National Laboratory and several U.S. universities, have been working for four years on ideas for a muon collider— a new lepton collider that, if scientists can make it work, would open up new windows on the energy frontier.

But the scientists have been doing the work mostly "on the side," said Bob Palmer, spokesman for the collaboration. Clearly pleased with the new developments, Palmer said that this first injection of substantial funding from DOE makes the collaboration a more formal entity and gives it "respectability."

Palmer also noted that the collaboration is expanding. Physicists from CERN, Oak Ridge National Laboratory and Indiana University have now joined.

DOE has allocated $1 million for the rest of FY1998 for work on a muon collider, including studies of radio-frequency cavities, cooling experiments and targetry R&D. The money will support research not only at Fermilab and other national laboratories, but also at Princeton University, the University of California at Los Angeles, the University of California at Berkeley and the University of Mississippi.

Also, DOE's university programs office has promised to provide support for a postdoc at the University of Mississippi, joining physicists Donald Summers and Lucien Cremaldi in studying some of the central problems in designing a muon collider. P.K. Williams, manager of DOE's university programs for high-energy physics, says that typically his office supports experiments, not the design and fabrication of accelerators. "This is a new direction for us," Williams said.

Finally, Fermilab Director John Peoples has slated a position for a university professor on sabbatical to study muon collider problems. Alvin Tollestrup, self-described "spiritual leader" of the muon collider program at Fermilab, is now busy recruiting.

For those interested in the physics of a muon collider, Fermilab will hold a workshop on May 22-23 to study the physics of the particle collisions and begin planning the design of the detector, taking into account the difficult "background"—showers of particles from muon decays that could overwhelm the triggering systems. According to physicist Rajendran Raja, organizer with theorist Joe Lykken of the workshop, the collaboration is looking for both theorists and experimentalists to participate. The theorists will decide which physical processes to simulate; the experimentalists will do the simulations.

"The allure of the machine is that it will have an energy reach comparable to the LHC's, but will be about the size of the Main Injector," said Summers.

The key to the design is figuring out how to cool the muons, that is, how to get them all in a tight little bunch marching in the same direction with the same energy. The problem is akin to that Fermilab faced in designing the proton-antiproton collider: how to cool off antiprotons. "We're repeating history," Summers said, "but with a different particle."

Whether the problem will be harder is not yet clear. "Once we complete our cooling solution, it may look easy," Summers said, "but right now we still have to prove the machine is feasible." ■

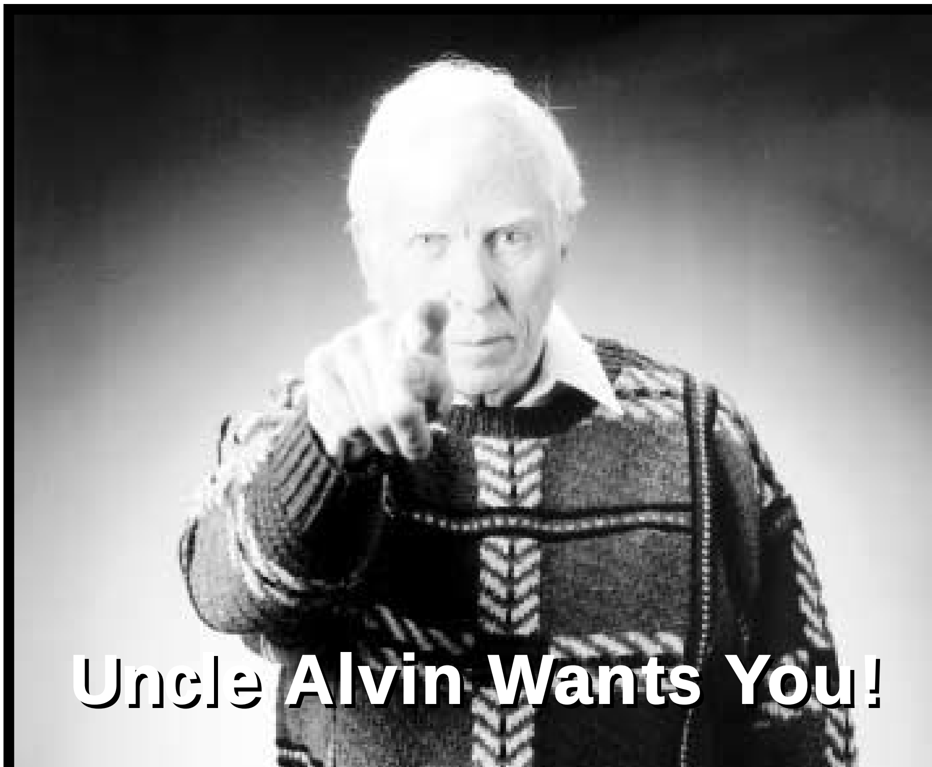


Photo by Fred Ullrich

The Muon Collider Collaboration seeks a university physicist to spend a Fermilab-paid sabbatical at the Laboratory investigating the physics possible with a muon collider and benchmarking detector design. Contact: Alvin Tollestrup, alvin@fnal.gov.

Dispatcher Roger Braun takes a call.

Hubert Kimmons-Mosby and Bill Stearns load a truck.

Carl Wheeler Sr. packs nitrogen cylinders onto a flat-bed truck.

Rick Heflin guides a forklift to load equipment.

Photos by Jenny Mullins

Life on the Road at Fermilab

"You name it, we've hauled it."

by Sharon Butler, Office of Public Affairs

The voice is familiar. The face is not.

It's Roger Braun, the cheerful dispatcher in the material distribution department.

The phone rings.

"Dispatch," says Braun, for the trillionth time in his 29 years at Fermilab.

Someone wants a taxi over in the Feynman Computing Center, and a second later, Braun has radioed one of his taxi drivers. "Computing," he says in the telegraphic language that's evolved over the years. The driver's voice crackles over the speaker: "10-4"—police code for "acknowledgment."

The taxi service at Fermilab is just a small part of a transportation network that gets things (and people) from point A to point B on this vast 10-mile-square campus, whether it's a one-ounce love letter or a 20,000-pound superconducting magnet, cylinders of propane gas or slabs of battleship steel. Everything that comes into, goes out of, or moves around the site passes through this truckers' outpost at Site 38, with a slip of paper for documentation filed away in Braun's tidy desk drawers.

At the hub of the network is Braun, ensconced behind a plate of glass in a spanking new facility that Braun considers a definite improvement over his old cramped office space in the milk house attached to the barn across the street.

Braun photographed every stage of the new facility's construction in 1994. "Looks like a convenience store," he grins. And he's right. If it weren't for the High Rise looming in the background, you might think you were out on the interstate, and had stopped by to fuel up at the pumps out front and pick up a bag of pretzels inside.

Behind his microphone in his glass-walled office, Braun looks like a deejay. He looked even more like a deejay back in the ’70s when a boom mike sat on top of his desk; now the two-way radio microphone fits in sleek black technology from Motorola.

From here, Braun controls the movements of 21 trucks and 10 semi-trailers, says George Davidson, supervisor for receiving, material distribution and vehicle maintenance. Every day, heeding Braun’s calls, vans and furniture trucks, straight trucks, flat beds and semis tool around the Fermilab site, picking up and delivering.

And every morning, Wally Kivisto, one of Braun’s drivers, picks up a gurney of mail at the Batavia Post Office. “I get Fermilab started in the morning,” he says.

Then he and the other drivers keep it going.

In the process, the oddest things happen. Once, long ago, drivers picked up trumpeter swans from the airport and carted them back to Fermilab, where efforts were being made to breed them. Once, too, at the airport they picked up a stuffed buffalo head, mounted by a taxidermist in St. Louis. It now hangs on the wall on the second floor of Wilson Hall. Today, drivers routinely transport injured wild animals found at Fermilab to the Willowbrook Wildlife Center nearby to be sutured and patched.

Braun remembers one guy calling for a cab to fetch him at Wilson Hall; when the cab arrived, the fellow asked to go to the Linac—just across the street.

Another prospective taxi customer once called and said, tartly, “You pick me up in Village,” and promptly hung up, not saying exactly where. The call came in twice more. Finally, the fourth time, the customer said, “You pick me up, you promised,” and slowed down long enough for Braun to find out finally where he was, before the dial tone set in.

Picking up multiton magnets is nothing unusual. These days the drivers are busy delivering dipoles and quadrupoles to the Main Injector, and must be sure to wrap them carefully in a tarpaulin to keep them clean and dry. “[Project managers] are fussy about dirt and weather,” says Wayne Smith, a veteran driver. And they’re fussy about speed. The drivers have to crawl from the Industrial Building to the Main Injector tunnel at a mere 10 miles per hour.

Handling prototype magnets for the Superconducting Supercollider was another matter. The magnets were built at Fermilab and had to be trucked all the way to Texas. The technical staff were worried that the journey might be deleterious to the magnets’ health. So, special flat-bed trucks were purchased, each sturdy and long enough to hold a 60-foot, 80,000-pound magnet, and each cushioned with air-bag suspension systems. Drivers were assigned, among them Smith, who remembers the motion sensors attached to the magnets, the giant fixture built just to set the magnets in place, the lights flashing at the end of the oversized load, and the trips around and around the Fermilab roads to test the magnets’ reaction—over bumps and potholes, around Sauk circle and in and out of turns.

“We’ve moved some strange stuff,” Braun says, adding. “You name it, we’ve hauled it.” ■

Fermilab Photo

Fermilab’s first cabs were two old school buses. According to Roger Braun, they had two routes: from the Village to Wilson Hall, and from Wilson Hall out to the bubble chamber.

Photo by Jenny Mullins

Fermilab’s taxi service today, with driver Sean Cannon.

Matter, Antimatter, and Why Are We Here?

CP violation may be the reason.

Photo by Fred Ullrich

Physicists long believed that fundamental physical processes would be identical in a world that was a mirror reflection of our own. But experiments in the 1950s showed that, for certain rare particle interactions, this mirror-image symmetry is broken. The broken symmetry in the behavior of matter and antimatter may explain the existence of the material universe.

by Meher Antia

Why do we exist? The age-old question has preoccupied philosophers for millennia—and physicists for decades. The philosophers ponder human purpose and destiny, but the physicists simply want to know why *anything*—people, rocks, stars —has a material composition. Physicists wonder why we are here, because, although there *is* a perfectly good reason for the entire universe to be no more than a seething mass of radiation, there appears to be no good reason whatsoever for there to be any matter at all.

When the universe exploded into being with the Big Bang, an equal number of particles and antiparticles sprang into existence. In close proximity, particles and antiparticles are extremely inhospitable: they immediately annihilate each other in a burst of light. Yet clearly the Big Bang produced something besides particle-for-particle annihilation. The universe now teems with matter, while physicists must laboriously create antimatter in huge particle accelerators. So when physicists ask why we exist, they are actually asking why, after the Big Bang, did more matter remain in the universe than antimatter? Paradoxically, one of the best ways to study such cosmic conundrums is to look closely at the innards of atoms, at the behavior of almost invisible subatomic particles at high energies. The answer to the physicist's "Why do we exist?" could lie with a seemingly insignificant particle, the *K* meson (or kaon), a tiny bit of matter that violates certain fundamental symmetries of nature.

The concept of symmetry is deeply ingrained in physics. Most symmetries are eminently sensible ones. For example, space has no intrinsic direction; there is a symmetry between left and right called parity (abbreviated P). If the length of a table is 20 inches measured from left to right, it does not suddenly become 21 inches when measured from right to left. Physicists long thought that all fundamental processes, from decaying particles to planetary motion, would look no different in a world that was mirror-reflected from our own.

Another symmetry, known as charge conjugation (abbreviated C), involved the behavior of matter and antimatter. If there existed a remote planet, just like ours but made

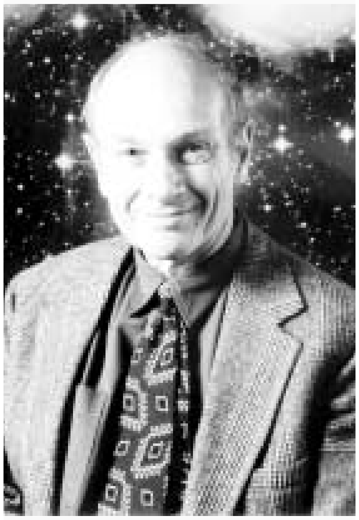


Photo by Reidar Hahn

In 1964, physicists James Cronin (above) and Val Fitch (below) discovered CP violation in rare decays of the K meson. In 1980, they won the Nobel Prize in physics for their discovery. Today, Cronin studies high-energy cosmic rays, whose collisions with atmospheric molecules create particles of antimatter. In fact, antimatter was discovered in cosmic-ray collisions.

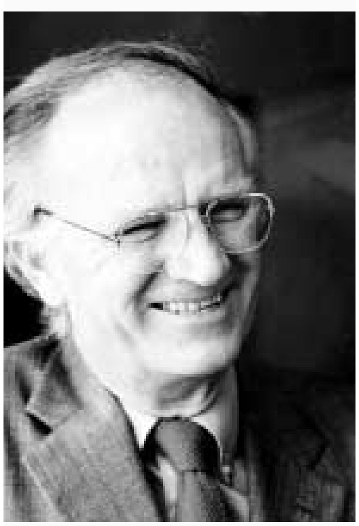


Photo by Bob Palmer

of antimatter, physicists believed there would be no way that people on the antimatter planet could know they were not made of the same stuff that we are. (Provided the two never came into physical contact and annihilated each other). If antiphysicists on the antiplanet performed the same experiments that physicists do to deduce the laws of nature, they would come up with laws identical to ours. Antiapples would still fall to antiearth, radioactive antielements would still decay, and antisugar would taste sweet. And the same would be true of a parity-reversed planet.

This happy state of affairs did not last long. By the late 1950s, experiments showed that certain rare interactions involving the weak force—the force responsible for radioactivity—violated both C and P. These violations came as a shock. They meant that if scientists living on a C- or P-reversed planet performed one of the C- or P-violating experiments, their results would look different from ours. There was indeed a way to distinguish matter from antimatter, and left from right.

But physicists recovered quickly from this unexpected blow. They found that, although nature did not always conserve C and P alone, it did appear to conserve both added together, in a symmetry called CP symmetry. Now it was no longer sufficient that a mirror-reflected planet alone could have the same laws of nature as we do. The planet also had to be made of antimatter.

Good-bye CP symmetry

In 1964, an experiment by physicists James Cronin and Val Fitch caused an uproar. Cronin and Fitch found that certain rare decays of the K meson violated CP. The neutral kaon, before decaying into particles called pions, exists in a strange schizophrenic state. Not quite able to make up its mind whether to be a particle or an antiparticle, it constantly switches between the two, existing first as the particle, then the antiparticle, then back to the particle and so on. In fact, its indecision is more complicated; it does the switching in two different ways. One type of kaon-antikaon mixture looks the same in a mirror; it is a symmetric state. The other is an antisymmetric state; its mirror image does not look the same. The symmetric state is supposed to decay into an even number of pions, the antisymmetric into an odd number,

continued on page 10

Fermilab Photo

In a universe made of matter, physicists must use powerful particle accelerators to create antimatter. When it is operating Fermilab's Antiproton Source, shown here, holds the world's largest supply of antimatter in the form of antiproton beams circling in a magnetic field.

CP violation

continued from page 9

so that the symmetry is preserved before and after the decay. Most of the time, the kaons behave themselves and decay just as they should, into two and three pions respectively. However, Cronin and Fitch found that one in every few hundred antisymmetric kaons decayed into two pions, not three. This seemingly innocuous result destroyed the belief in CP symmetry.

For years, physicists tried to find alternative explanations for the observed decay of the kaon, but none stood up to experiment. Eventually, they had no alternative but to abandon CP symmetry. This was disturbing, in a way that is perhaps difficult to understand, because everyday life is so riddled with asymmetries that it might seem that symmetries are the exception rather than the rule. For example, a wine glass can easily shatter into a thousand pieces, but a thousand pieces of broken glass never spontaneously reassemble into a wine glass. The letters of the alphabet look nonsensical when reflected; the real alphabet is easily distinguishable from its mirror image.

But neither a shattering wine glass nor the alphabet is governed by any *fundamental* law. A glass breaks but does not reassemble because it starts out in a very special condition; its atoms are arranged in an orderly form that took work to create. Broken, its atoms assume one of billions upon billions of possible disordered arrangements, a situation overwhelmingly more likely than the wineglass's ordered arrangement. In the same way, the alphabet and the gibberish in the mirror only seem distinct to us because we start out with a preconceived notion of how the letters look. To a person familiar only with Chinese characters, say, the alphabet and its mirror image look equally meaningless.

A decaying kaon, however, is described by truly fundamental laws of nature. It should be truly indifferent to whether it decays in this world or in a CP-reversed world. The fact that it distinguishes between them meant that nature had cavalierly chosen one set of laws over another set of equally plausible ones. This seemingly arbitrary behavior shook physicists and forced them to reconsider the intricacies of the physical universe.

Kaons and the early universe

As physicists recovered from the shock of the Cronin and Fitch experiment, they incorporated the mysterious behavior of the kaon into the grand scheme of particle behavior as expressed in the Standard Model. It allows for CP violation to occur if more than two sets, or generations, of quarks exist. And indeed, physicists have discovered three generations of quarks: the up and down quarks, the strange and charm quarks and the top and bottom quarks. University of Chicago physicist Bruce Winstein likens the three generations of quarks to the presence of three sets of dance partners

Photo by Reidar Hahn

Rutgers University graduate student Eva Halkiadakis works in the KTeV control room.

For years, physicists tried to find alternative explanations for the observed decay of the kaon, but none stood up to experiment.

rather than two. With only four dancers, if one couple decides to pair up for a dance, the other couple has no choice but to dance with each other. With three couples, however, even if one couple has paired up, the other four dancers still have some choice in partners.

In the same way, three generations of quarks have a freedom to explore choices of combinations that would not be open to them if there were only two generations. So as the kaon is vacillat-ing between being a particle and an antiparticle, the quarks within are busy exploiting their freedom to explore CP-violating options that would not otherwise be open to them.

In the Standard Model explanation, the antisymmetric kaon-antikaon mixture decayed symmetrically into two pions because it was somehow contaminated with a little bit of the symmetric mixture. The CP violation did not occur in the decay process itself, but rather had its roots in the mixing of the particle and antiparticle. CP violation due to such mixing was termed indirect CP violation. However, the Standard Model also predicts direct CP violation, a result of the actual decay of the kaon. If direct CP violation exists, it means there is a fundamental difference in the way the laws of physics treat matter and antimatter.

And therein lies the link to the excess of matter in the universe today. If there were no CP violation, the laws of the universe would have no way to distinguish the decay process of the kaon or antikaon. But at some point soon after the Big Bang when particles were scooting all over the place decaying, combining, creating new particles and annihilating others, there was an excess of matter over antimatter. The asymmetry between kaons and antikaons could very well be related to this early excess in the universe.

So the answer to the physicist's "Why do we exist?" may possibly be "Because of CP violation." As a result, physicists naturally have a tremendous interest in trying to detect and measure direct CP violation. Is the effect big enough to account for all the matter in the universe? Does the Standard Model correctly predict the magnitude of the effect; and, if not, could CP violation lead to physics beyond the Standard Model? In search of answers to these questions, accelerator laboratories around the world have poked and prodded the kaon, but the effect is so incredibly tiny—a thousand times smaller than the already minuscule indirect CP violation—that all experiments to date have come up empty handed.

The latest effort to measure direct CP violation at Fermilab, by the KTeV collaboration, completed the first round of data-taking in September 1997. Unfortunately, simply measuring the decay rates of the kaon and antikaon is out of the question because the rates are so similar that it would require billions of events to detect any difference. Instead, the experiment relates CP violation to the different rates of decay of the antisymmetric mixture of the kaon: into two neutral pions or into two charged pions, a ratio that is difficult but not impossible to measure.

continued on page 12

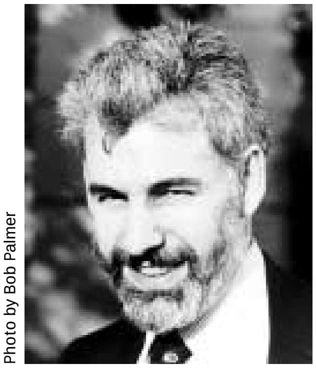


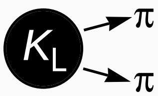
Photo by Bob Palmer

University of Chicago physicist Bruce Winstein, cospokesman of Fermilab's KTeV experiment, whose goal is to study CP violation and kaon decays with unprecedented precision.

If direct CP violation exists, it means there is a fundamental difference in the way the laws of physics treat matter and antimatter.

Indirect and Direct CP Violation in Kaon Decay

Symmetric neutral kaons , called K_1, decay into two pions. Antisymmetric neutral kaons, K_2, usually decay into three pions. However, because each of the two kaon states is "contaminated" with a tiny amount of the other, once in about 500 times, the state that is mostly K_2 (called K-long or K_L), decays into only two pions, violating CP symmetry, in a phenomenon called indirect CP violation.



(CP violating)

When this happens, the two pions may be neutral (π^0) or electrically charged (π^+, π^-). Fermilab's KTeV experiment measures the ratio of these two kinds of neutral kaon decays with extreme precision. Experimenters combine these measurements with measurements of CP-conserving two-pion decays for short-lived kaons (K_S). If experimenters find that the ratio of these decays does not equal 1, that would be evidence of direct CP violation, in which the decay itself violates CP symmetry.

CP violation

continued from page 11

In the KTeV experiment, a proton beam veers off from the main accelerator ring and smashes into a fixed beryllium target. The collision spews out kaons, along with other elementary particles. About 20 million kaons are generated every second, explains Bob Hsiung, a Fermilab physicist. Of the 20 million, about one million decay in the experiment. Of those, only about a thousand decays per second are recorded onto tape to be analyzed later. Going from a million events to just a thousand means that even before the data are stored, they are painstakingly sorted so that only events that yield potentially useful information make it all the way to storage. Much of the 200-meter-long experiment is dedicated to expelling unwanted particles. For the first 100 meters, collimators create two parallel beams, and magnets sweep away all charged particles, leaving only neutral ones behind. Veto detectors identify and discard the uninteresting CP-conserving decays of the kaon.

The neutral pions decay to photons, which zip all the way through the vacuum decay region, magnetic fields and scintillators until they reach a calorimeter, a huge array of cesium iodide crystals attached to 3,100 photo-multiplier tubes. The photons deposit their energy in the crystals and are duly recorded. The charged pions from probable CP-violating decays are recorded, after wire chambers and scintillators mark out their trajectories and magnets determine their momenta. Again, if the instruments deem them interesting enough, they are stored for future scrutiny.

The computational power to make instant decisions on which events to veto and which to keep makes experiments of this sensitivity possible. The number of raw events is staggering. Even the small fraction of data that eventually gets stored uses 40 million million bytes. While it is impossible to analyze every event, there is also a danger in making detectors that trigger only on events predicted

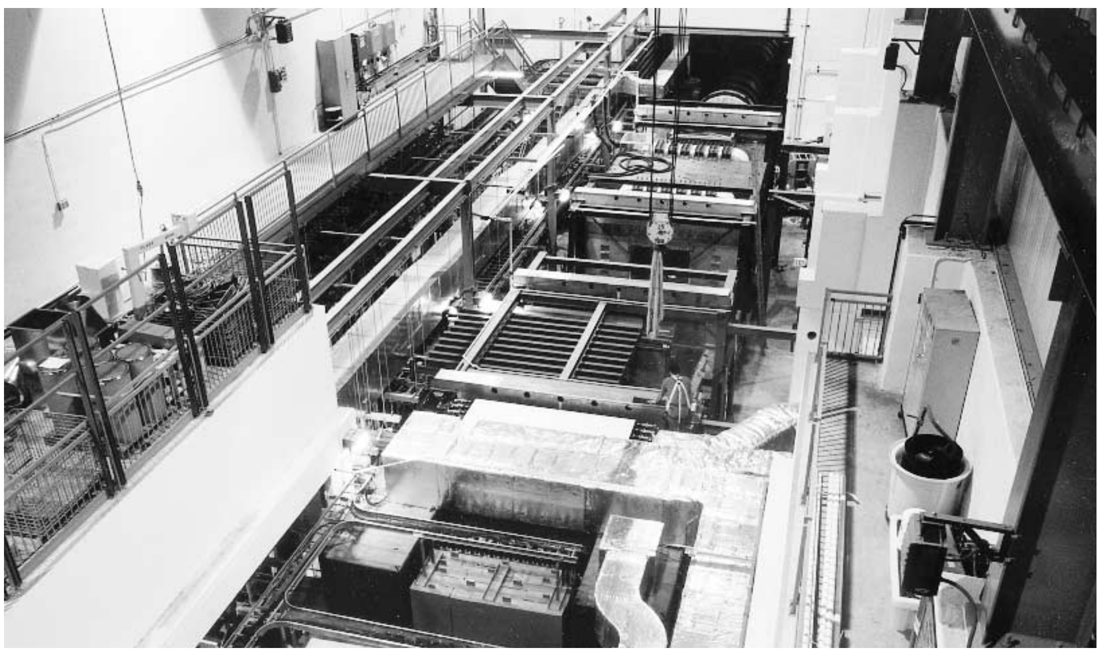
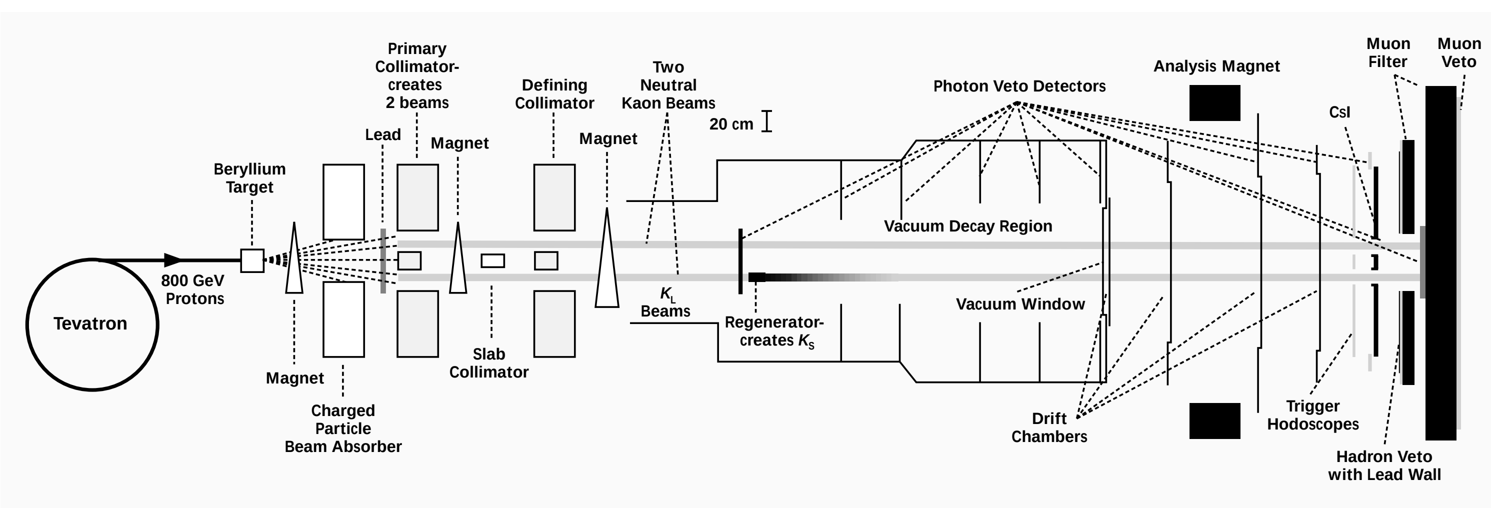
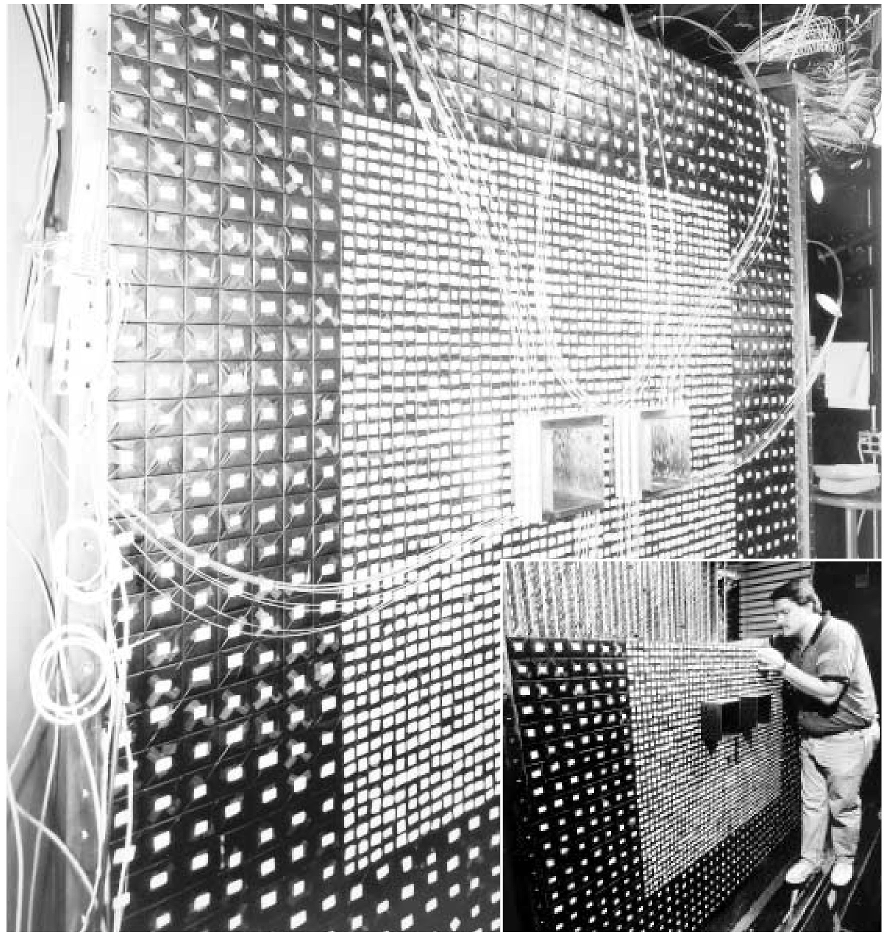


Photo by Reidar Hahn

The KTeV experiment starts with a beam of protons from the Tevatron. Magnets and collimators create parallel beams of neutral kaons, some of which decay in the experiment. Detectors measure the decay products, “vetoing” uninteresting CP-conserving decays and recording the ones that violate CP symmetry.



KTeV's cesium iodide calorimeter just after ▶ completion in August, 1996. (Inset: Earlier, University of Chicago physicist Aaron Roodman stacked a crystal in the calorimeter.) The calorimeter detects the energy of photons from the decay of pions produced in neutral kaon decays.



Photos by Reidar Hahn

Fermilab physicist Herman White, with photon veto counters for KTeV, before their installation in the experiment's beamline. The veto counters reject particles at very large angles to the beam line, to rule out false decay signals.

by the Standard Model. Something completely new could easily be missed, says Bob Tschirhart of the KTeV collaboration. There is a constant struggle to strike a balance between making triggers that are lenient enough to admit quirky yet meaningful data, and strict enough to discard junk.

KTeV has only begun combing through the mountains of data. Although there is as yet no hint of direct CP violation, the collaborators have discovered an extremely rare kaon decay into a charged pion pair and an electron-positron pair. This rare decay mode will offer a new window on CP violation.

What will come out of KTeVs roomfuls of sophisticated equipment and the masses of data will not be merely a mathematical jumble of numbers and formulas, but a simple concept that could shed light on why we're all here in the first place. ■

Meher Antia is a freelance science writer.

FermiNews Essay Contest

Champagne's on ice—start writing!

Deadline May 5, 1998

As announced in the last issue, *FermiNews* will award a bottle of Dom Pérignon as the first prize, and Congressman Verh Ehlers will award an American flag flown over the U.S. Capitol as the second prize for the best essays of 500 words or less to address the question "Why should the U.S. remain a world leader in high-energy physics?"

Submit essays by e-mail (ferminews@fnal.gov); snail mail (*FermiNews*, MS 206, Fermilab, P.O. Box 500, Batavia, IL 60510); fax (630-840-8780); or in person (Wilson Hall, 1 East.)

For more information, call the Fermilab Office of Public Affairs at 630-840-3351, or see the Essay Contest page on the World Wide Web: http://www.fnal.gov/pub/essay/contest.html

Peña Provided Fermilab With LHC Legacy

DOE Photo

Secretary of Energy Federico Peña (left) and CERN Council President Luciano Maiani signed the LHC agreement in Washington's Old Executive Office Building on December 8, 1997.

By Mike Perricone, Office of Public Affairs

Secretary of Energy Federico Peña announced his resignation just 15 months after being appointed, but his brief tenure has had a significant impact on Fermilab.

Peña signed the agreement committing the U.S. to help build the accelerator and two of its associated detectors for the Large Hadron Collider (LHC) and CERN, the European Laboratory for Particle Physics in Geneva, Switzerland.

"When we sign this agreement," Peña said in Washington at the December 8, 1997, ceremony, "it will mark the first time the U.S. government has agreed to contribute significantly to the construction, through domestically produced hardware and technical resources, of an accelerator outside of our borders."

The U.S. contribution, largely in the form of accelerator and detector components built in the U.S. to be delivered to CERN, totals $531 million over eight years, with $450 million in funding from DOE and $81 million from the National Science Foundation.

"This will help make us a credible host for the construction of a future higher-energy collider," said Jim Strait of Fermilab's Technical Division, project manager for the U.S. contribution to the accelerator, leading a collaboration that also includes Brookhaven and Berkeley Lab.

"The only way such large facilities can be built is by a worldwide collaboration," Strait continued, "and our contribution to the construction of the LHC will help establish the principle and habit of accelerator builders working across international boundaries."

Peña, a lawyer and former mayor of Denver, also served as Secretary of Transportation in the first Clinton Administration. In his announcement on April 6, he said he would not seek elective office and would instead work in private industry when he steps down in June.

Peña, 51, cited the need to spend more time with his family as the reason for resigning. He and his wife have three children, aged 7 years, 6 years and 9 months.

"Ellen and I have three wonderful children and it is now time to focus on their futures," Peña said during his press conference. "If you talk to people who have come to Washington, whether members of Congress or members of the Administration, they all understand."

Deputy Secretary of Energy Elizabeth Moler will be named Acting Secretary, and is a likely candidate to succeed Peña. ■

" This agreement will mark the first time the U.S. government has agreed to contribute significantly to the construction… of an accelerator outside of our borders."

~ Secretary of Energy Federico Peña

Photo by Reidar Hahn

Kids and hot dogs, trees and Web pages, and the whole universe in a jar—April 23 will be a day for smiles at Fermilab.

'Daughters and Sons to Work'

Joins Earth Day on April 23

By Mike Perricone, Office of Public Affairs

Plant a tree, eat a hot dog, make your own Web page, see a super-cool show and come home with the universe in a jar.

Thursday, April 23, is the third annual combined Earth Day-Daughters and Sons to Work Day at Fermilab. Kids can start the day by finding out what their parents do at the Lab, and then write their impressions for the annual special edition of our *FermiKids* newsletter.

If you'd like to volunteer to help out that day, contact the Office of Public Affairs at extension 3351, or e-mail Luann O'Boyle (luann@fnal.gov).

Volunteers are also needed to be "mentors," spending an hour at some point in the day between 9 AM and 2 PM with a kid who'd like to learn what someone else does at the Lab. If you don't have a child, or aren't bringing one on April 23, but would like to share some time one-on-one with a child during Daughters and Sons to Work Day, this is a special opportunity.

Kids (and grown-ups) participating in the Earth Day tree planting will have a hot dog lunch. You can also sign up for lunch in the cafeteria, but you must have reservations (630-840-3351).

The Lederman Science Center, open all day, is the site of a special "Design Your Own Web Page" project hosted by members of Fermilab's Computing Division. Jerry Zimmerman performs the popular Cryo Show, while younger kids will enjoy Clifton Horvath's laser demonstration. Kids of all ages will love creating a universe-in-a-jar of their very own.

And for the first time, we'll take a group photograph of everyone attending Earth Day / Daughters and Sons to Work Day at Fermilab—where science is way cool. (Ask your kids what that means.) ■

MILESTONES

HONORED

Photo by Reidar Hahn

■ Ryan Swain, 21, former Fermilab summer undergraduate student, named to the first team of the '98 All-USA College Academic Team, by USA Today received a $2,500 cash award. Awardees are nominated by their schools. The criteria: grades, academic awards, leadership roles & public service.

Ryan Swain of Temple, Ga

Alabama A&M U., Normal.

Major: Applied physics.

GPA: 3.94

Career Goal: Robotic engineer

Achievements: At Fermilab, designed and built prototype of liquid level capacitance helium probe; during NASA-funded research, developed soil-moisture sensor that achieved highest sensitivity ever recorded; tutor, Coalition for At-Risk Minority Males.

Professor's comment: Ryan has a willingness to sacrifice personal gratification for the benefit of a greater cause.

Parents: Elijah, Lula Swain.

BORN

■ Nicole Tartaglia, April 10, to Heidi and Mike (TD), at Edward Hospital.

INSTALLED

■ The first permanent magnet for the Recycler, on April 3, 1998. The contract for installing the remaining 343 magnets was awarded on Monday, April 6. A partial shipment of specially-treated nickel-iron alloy for the permanent magnets had been lost, along with a huge shipment of expensive French wine, when the MSC *Carla* sank in a storm off the Azores on November 25, 1997.

Photo by Reidar Hahn

Gerry Jackson of the Main Injector Department adds his support to the first permanent magnet installed for the Recycler.

Chez Léon

MENU

Lunch served from
11:30 a.m. to 1 p.m.
$8 / person
Dinner served at 7 p.m.
$20 / person

For reservations, call x4512
Cakes for Special Occasions
Dietary Restrictions
Contact Tita, x3524

Lunch Wednesday April 22

Spanakopita
(Greek Spinach and Cheese Pie)
Greek Salad
Walnut, Honey and Anise Tart

Dinner Thursday April 23

Antipasto
Sea Bass with Sorrel Sauce
Sauteed Cherry Tomatoes
Oven-Baked Polenta
Orange Olive Oil Cake

Lunch Wednesday April 29

Chili-crusted Flank Steak with Mango Salsa
Black Beans and Rice
Banana Cake with Chocolate Ganache Glaze

Dinner Thursday April 30

Spinach Fettuccine with Smoked Salmon and Asparagus
Grilled Duck Breast with Fig and Red Wine Sauce
Wild Rice with Almonds and Raisins
Fresh Fruit Tart

CLASSIFIEDS

FOR SALE

■ ’94 Intrepid, 73K miles, very clean, all original paperwork. Needs to be seen (1310 Wintergreen, Batavia), $8,300. Del Hoffman (630) 879-2377.

■ ’94 Toyota Corolla, 48K miles, 4 dr, at, ac, Premier sound w / cassette, 1 owner, exc. condition, asking blue book price $9,200. Contact Steve, (630) 978–1627 or kuhlmann@fnal.gov.

■ ’91 Nissan 240 SX SE, Hatchback, 62K miles, Auto, air, PDL, PW, Tilt, Cruise, Sunroof, Spoiler, rear wiper, alloy wheels. Red & ready, needs nothing, $6,750. Call Ed Dijak, x6300, or (630) 665–6674, dijak@fnal.gov.

■ ’91 Honda CRX HF, 2-dr hatchback, white, manual trans, 60 HP, 68K miles, dependable, new tires, high mpg, 10 cu. ft. trunk, $5,000 obo. Contact Patricia Ball, pball@fnal.gov, x3748 or (708) 660–9268.

■ ’88 Ford Taurus, good condition, 72K miles, reliable, $2,400 obo. Call (630) 761-9848 & leave message.

■ ’88 Nissan Sentra. Very reliable, 2 dr, automatic, 100K miles. New timing belt, water pump, thermostat, etc. $1,900 obo. (630) 243–1125.

■ ’84 Olds Cutlass Supreme, 2 dr, sport coupe, rally wheels, pioneer pull-out stereo. New brakes, tires & exhaust. Dependable, clean vehicle. Moving must sell, $1,800. (630) 443–9881.

■ ’80 Kawasaki 440 LTD motorcycle, only 4,500 miles, $600. Call Pam x3377.

■ Macintosh Performa 475, $225 obo. Includes external hard drive, CD ROM, Image Writer printer & software. Call x8030 for details.

■ 1998 Chicago Bears season tickets. One pair at Soldier Field, decent seats, section 31, row 39. 2 pre-season games & 8 regular season. Prefer to sell both tickets for whole season (at cost) for $663. Call Sandy, (630) 879–9265 or slivi@interaccess.com.

■ Golf Clubs, Cobra metal woods, Titanium driver, 3 & 5 woods, regular flex graphite shafts, exc. condition, $300. Jim, x4293 or (630) 585–0907.

■ Home, ranch, Summerlakes, 2 mins from the east gate, Warrenville. Newly remodeled kitchen, new roof, fenced yard, $115,000. Call Patricia, (630) 393–6569 for an appointment.

RENT

■ House, Aurora / Naperville area, available 6 / 1, 3 bdrm, 1 bath, fenced yard, 2.5 car garage, 10 miles south of lab. $1,100 / mo., 1 yr. lease. Call Ed Dijak, x6300 or (630) 665–6674, dijak@fnal.gov.

■ House, $500 / mo + utilities. Furnished, east side Lathem Street, Batavia. Call for an appointment, (630) 554-9711 or 898-0962 x109.

CALENDAR

APRIL 17

Fermilab Lecture Series presents: John A. Larson, Archivist, Oriental Institute, The University of Chicago, *Chicago and Egyptology, The Legacies of James Henry Breasted*. Ramsey Auditorium, 8 p.m., admission $5.

APRIL 18

Tornado and Severe Storm Seminar presented at 1 p.m. and again at 7 p.m. Ramsey Auditorium, Free admission.

APRIL 21

Wellness Works presents: Blood Pressure Screening, noon - 1 p.m. Atrium by Credit Union.

APRIL 24

Fermilab International Film Society presents: *Chasing Amy*, Dir: Kevin Smith, USA (1997). Admission $4, in Ramsey Auditorium, Wilson Hall at 8 p.m.

MAY 2

Fermilab Art Series presents: Paula Robinson, flute, and Eliot Fisk, guitar, $19. Performance begins at 8 p.m., Ramsey Auditorium, Wilson Hall. For reservations or more information, call 840-ARTS.

MAY 8

Fermilab Lecture Series presents: Dr. Siegfried S. Hecker, Former Director Los Alamos National Lab, *From Russia with Love: A Scientist’s Journey through the End of the Cold War*. Ramsey Auditorium, 8 p.m., admission $5. Call (630) 840-ARTS for tickets.

ONGOING

NALWO coffee mornings, Thursdays, 10 a.m. in the Users’ Center, call Selitha Raja, (630) 305–7769. In the Village Barn, international folk dancing, Thursdays, 7:30–10 p.m., call Mady, (630) 584–0825; Scottish country dancing Tuesdays, 7–9:30 p.m., call Doug, x8194.

Conversational English classes, 9–11:30 a.m., Thursdays, in the Users’ Center.

Je suis Francaise. J’enseigne le Francais. Peggy-Henriette Ploquin. (630) 682-9048.

LAB NOTES

‘98 Fermi Coed Softball League.

We’re looking for guys & gals of any skill level to come out and enjoy some fun and some sun Wednesday and Thursday nights. Games will be held at 5:30 and 6:45 at the Fermi softball field in the village. The season starts May 13 (weather permitting), so don’t delay and miss out on the best thing around this summer! If you have a team together, or would like to join a team, please contact: Chad Gundelach, x2813, gundelac@adms21.fnal.gov; or Jean Guyer, x2548, jeanm@fnal.gov.

Eurest Dining Services on the Web

Check it out: fnalpubs.fnal.gov / eurest / Eurest.html

Sitewide Power Outage

Monday, April 20 and Friday, May 1 from 7:00 am to 7:10 am. During this ten minute period Fermilab will be on restricted power.

SI NON VIS IMPRIMI NOLI PATI FIERI
FERMINEWS MCMLXXVII

FermiNews
Fermi National Accelerator Laboratory

Published by the
Fermilab
Office of Public Affairs
MS 206
P.O. Box 500
Batavia, IL 60510
630-840-3351
ferminews@fnal.gov

Fermilab is operated by Universities Research Association, Inc., under contract with the U.S. Department of Energy.

The deadline for the Friday, May 1, 1998, issue of FermiNews is Tuesday, April 21.

Please send your article submissions, classified advertisements and ideas to the Public Affairs Office, MS 206 or e-mail ferminews@fnal.gov.

FermiNews welcomes letters from readers. Please include your name and daytime phone number.

☆ U.S. GOVERNMENT PRINTING OFFICE:
1998--646-054/81002

50%
TOTAL RECOVERED FIBER
10% POST-CONSUMER FIBER