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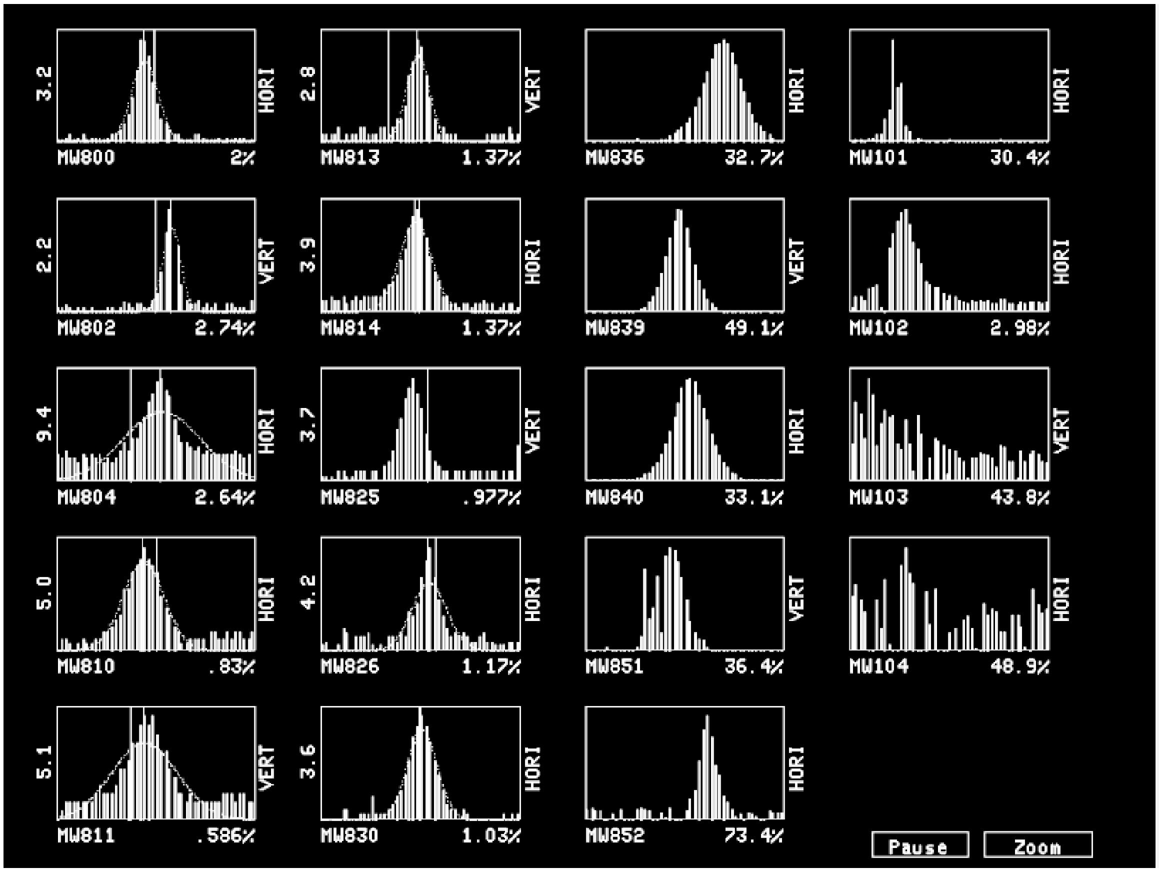

The evidence is in, as displayed in this beam profile from the Beams Division's electronic commissioning log. On September 26, beam enters the new 8-GeV line at location MW800 (upper left), runs through to location MW852 and moves into the Main Injector at location MW101 (upper right). Beam begins to dissipate at MW103 and MW104, and then is lost.

Onward and Upward

The Main Injector sees beam for the first time, and Fermilab begins a countdown to the future.

by Mike Perricone, Office of Public Affairs

Beam edged into the Main Injector on Saturday, September 26, 1998, a long-awaited milestone for the eight-year, $229-million project that had removed thousands of cubic yards of earth and replaced them with thousands of cubic yards of concrete, creating an underground chamber where tens of thousands of tons of magnets and millions of watts of electricity will combine to propel a hair-thin stream of subatomic particles at nearly the speed of light, flashing around this new two-mile track nearly 100,000 times per second, heading for unexplored destinations in the realm of thought.

The pioneering stream of protons started out on a route they've taken before, beginning at the Cockroft-Walton pre-accelerator, speeding down the Linac corridor and swirling around the Booster.

The protons swung through the gradual curve of the new 8-GeV line without

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INSIDE

The Witnesses

On hand for the first beam in the Main Injector:

John Peoples
Director

Steve Holmes
Beams Division Head

Main Injector Department:
Dave Capista
Phil Martin
Shekhar Mishra
Saeed Assadi
Ioanis Kourbanis
Dave Johnson
Stan Pruss
Alan Hahn
Ming-Jen Yang

Proton Source:
Jim Lackey
Milorad Popovic

Advanced Accelerator Technology:
Carol Johnstone

Instrumentation:
Jim Crisp
Greg Vogel
Ed Barssott
Gianni Tassotto
Rick Pierce

Electrical/Electronics Support:
Steve Hays
Bob Flora
Kevin Martin
George Krafczyk
Dan Wolff

Controls:
Ann Mason
Brian Hendricks

Operations:
Bob Mau
Dean Still
Brian Drende
Operations Crew

(For more information on the Main Injector, see http://www-fmi.fnal.gov.)

Taking a breather from the Saturday afternoon activities in the Main Control Room are (left to right) Shekhar Mishra, Main Injector Department Head Phil Martin, Beams Division Head Steve Holmes, and Steve's son, Eric.

hesitation, then met the critical test: a magnetic kick over the threshold into the Main Injector itself.

At 4 p.m. on this quiet autumn Saturday, more than seven hours after power was turned on in the main magnet circuit, the evidence for beam was unmistakable. The team that had worked on this new accelerator since its earliest stages, the team that had assembled itself in the Main Control Room to watch the computer screens and to be on hand for any "What if..." issues, now had seen the payoff.

"I appreciate the help and dedication of everyone present at the MCR [see the accompanying witness roster], including many I must have forgotten to name," said Shekhar Mishra of the Main Injector Department, who is directing the commissioning of the new machine. "But this success belongs to everyone all across Fermilab divisions, and to more than 200 people who have worked very hard for several years in building the Main Injector.

"We did have a small celebration," Mishra continued, "but not an official one. I think we might celebrate when we circulate beam through the entire machine. That means we'll have to wait, but that's OK. There's much more to come."

Beam first entered the Main Injector at the MI101 location, registered with the toroid (TOR103) at MI103, passed MI104, then dissipated between locations MI105 and MI106. Total distance of penetration into the Main Injector: about 35 meters (100 feet).

"(The distance) was not important," Mishra said. "Our goal was to get the beam to this toroid, which is the beam intensity counter at the 103 location. That was our goal, and that's what we managed to achieve."

Toroids are doughnut-shaped electromagnets, wound with a coil, used to measure the intensity of the beam at various locations along the beam path. The Booster injected $5x10^{11}$ protons per pulse, every 30 seconds, into the 8-GeV (also called MI8) line; toroids in the Booster, at the beginning and end of the transfer line, and at the entry to the Main Injector registered similar beam intensity.

CRITICAL PATH

The beam stopped at the next dipole magnet, which was no surprise: the dipole was receiving no power, so the protons had nowhere to go. Without the dipole magnet to steer them, the protons took off on a tangent to their original curved path. The dipole essentially acted as an abort, or dumping point. This journey was far enough for the first day.

"The magnet wasn't turned on because we didn't want the beam to go past that point," Mishra explained. "The reason for stopping at that first toroid is that work by the contractors and Fermilab staff is still going on in the tunnel. We do not irradiate the tunnel while people continue to work there during the week. Another reason is that several subsystems are still being worked on. It's better to proceed with the Main Injector commissioning in steps, as planned."

The first step of the commissioning plan, set in place six months ago, called for introducing beam into the 8-GeV / MI8 line and into the Main Injector on the first weekend. Once beam had traveled that far, the next step for the next weekend called for sending beam halfway around the ring to the abort, located at MI40. That step was accomplished on Saturday, October 3, after several hours of tuning the injection corrector magnets, and the main dipole magnet strength, to keep the beam path centered in the magnet aperture.

"Once we tuned the (Main Injector) section of the beam line, beam was visible all the way through to the MI42 beam position monitors," Mishra said.

The next step, targeted for October 10: circulating the entire Main Injector ring with an 8-GeV "coasting beam," aiming for several turns around the two-mile circuit.

Commissioning beam is one of the three major activities at the Main Injector on the weekends, along with commissioning of the power supplies, and of instrumentation and control. The commissioning schedules are flexible; Mishra, who formulates the schedule, said no one is stopped on the hour if there's more work to be done.

"This is a collaborative effort," he emphasized.

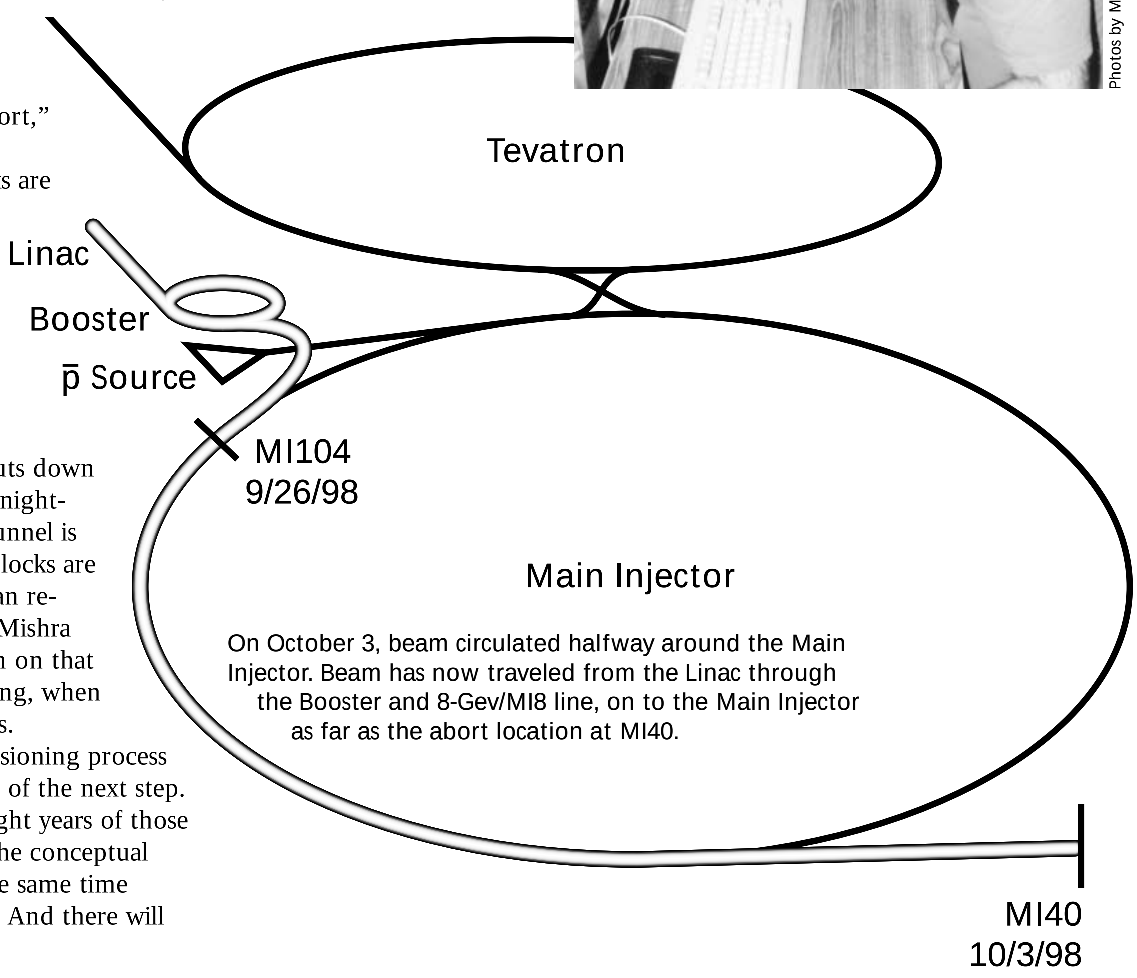
On Friday nights, the locks are changed on every door to the Main Injector tunnel and integrated into the radiation safety system. The tunnel is searched and secured, to make sure no one is inside, and only then are the Main Injector quadrupole and dipole buses turned on. Commissioning shuts down just after midnight on Sunday night-Monday morning, when the tunnel is surveyed for radiation and the locks are changed back so contractors can re-enter the tunnel by 5:30 a.m. Mishra said commissioning will remain on that schedule until after Thanksgiving, when full-time commissioning begins.

Mishra knows the commissioning process is always judged by the success of the next step. There have been more than eight years of those "next steps," beginning with the conceptual design report written about the same time Mishra joined the department. And there will be many more next steps until the entire accelerator complex is up and running for Run II of the Tevatron.

"A lot of people have put a lot of effort into this project, and I think the real excitement has just started," Mishra said. "We still have quite a lot of work ahead of us. We have to accelerate beam through the entire Main Injector and deliver it to the Tevatron at 150 GeV, to support Fermilab's high-energy physics research program. That's the ultimate goal. Until then, we have what you might call step-up excitement." ■

At about 4:08 p.m. on September 26, Phil Martin sees evidence on the monitors that beam has crossed over into the Main Injector.

Photos by Marty Murphy



On October 3, beam circulated halfway around the Main Injector. Beam has now traveled from the Linac through the Booster and 8-Gev/MI8 line, on to the Main Injector as far as the abort location at MI40.

DZero's Solenoid:
READY TO ROCK

The first major piece of equipment for DZero's upgrade is commissioned.

"This magnet is particularly solid and rugged— I don't know any other word for it."

~ Rich Smith, DZero physicist

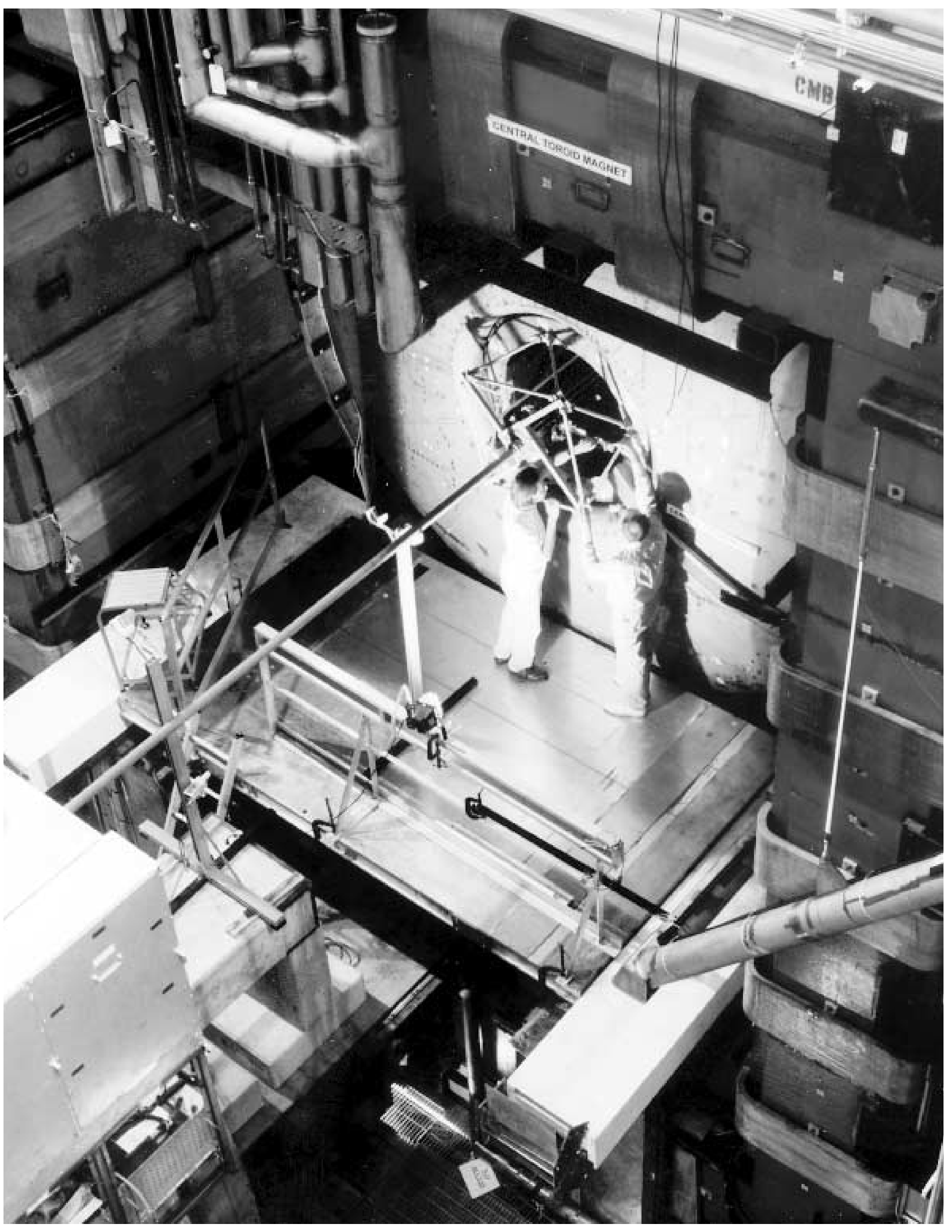
by Sharon Butler, Office of Public Affairs

The e-mail message that flew over the network was simple to the point of understatement. No exclamation points, just: "Gentlemen: The D0 solenoid reached 2.0 Tesla this afternoon without upset or complication."

Without upset, indeed. Harry Weerts, cospokesperson of the DZero collaboration, said the powering of the giant superconducting magnet, a major upgrade for the detector, was so "eventless" that the scientists feared they were missing something.

At last, after running multiple performance tests, they conceded all was well.

Director John Peoples, thrilled with the success, congratulated the DZero physicists and engineers involved in the project, including Gene Fisk, who was in charge. Peoples guessed, though, that the scientists were even more elated than he, because they understood why the task was so challenging: "They knew what could go wrong, and it didn't because they did everything right," Peoples said.



At center stage, inside the central bore of the DZero detector, is the collaboration's new solenoid, partly obscured by the frame of the fieldmapper.

Photos by Reidar Hahn

The magnet

The DZero solenoid looks like a big open tin can sitting in the middle of the central calorimeter of the detector. It won't win any beauty contests, but it should extend considerably the physics capability of the DZero experiment, especially in *b*, or beauty, physics. DZero didn't have a magnet in Run I, when it depended on its precision calorimeter and hermetic muon system to study particle collisions. With the solenoid in place, the collaboration will be able to measure directly the transverse momenta of the charged particles that scatter in every direction as protons and antiprotons collide.

Instead of a continuous beam in the Tevatron, picture bumble bees colliding head-on (since the protons and antiprotons come in bunches), but bumble bees a fraction of the width of a human hair, all in a line entering the detector from both ends. Occasionally they crash head-on, creating swarms of new particles that fly off in every direction. New silicon and fiber detectors inside the solenoid will track the particles as they scatter, following paths curved by the solenoid's magnetic field. Knowing the curvature of the particles' paths and the intensity of the magnetic field at each location along these paths, DZero physicists will be able to calculate the momenta of all those bee parts.

In fat city

Commissioning the magnet involved reassembling the solenoid, control dewar and interconnecting chimney after their long trip across the Pacific from Toshiba's Keihin Works, in Yokohama, Japan; cooling the system; and then energizing the magnet to reach the magnetic field strength it was designed to achieve, two Tesla.

At each stage, there was opportunity for trouble. After all, the five-ton package had been hauled to a dock in Japan, bounced around on an ocean liner, off-loaded onto a truck in California, and jostled on interstate highways all the way to Batavia. Contents might have been damaged. The Fermilab team was especially concerned about the fiberglass suspension system, used to fix the magnetic coils in the solenoid to the surrounding cryostat. Fiberglass is the ideal material: it doesn't readily conduct heat (the coils need to be supercold), and it insulates against stray electrical currents. To prevent undue stress on the fiberglass parts, special steel bolts were added during shipment to hold the coils in place, and removed once the solenoid docked safely at Fermilab.

Another potential problem: At room temperature, the solenoid stands at 300 degrees Kelvin. At operating temperature for testing, the magnet had to be cooled to a frigid 3 degrees Kelvin. That's a terrific change in temperature for any material, especially a composite of metal and plastic. Fractures can develop as the materials contract in the cold, each at its own pace. To prevent cracks and minimize thermal gradients in the coils when the magnet was readied for testing, it had to be cooled ever so slowly, with precise control.

CRITICAL PATH

Superconducting magnets are also notoriously temperamental, said physicist Rich Smith, who, with other DZero scientists and engineers, has been testing the solenoid. The magnets can be difficult to charge and discharge; they can trip off without notice. The Fermilab team paid close attention to certain design features and fabrication methods to forestall any such problems in the DZero solenoid. Testing in Japan proved them successful.

And so, Smith figured, "If nothing got damaged during shipment, if we didn't make a mistake putting the solenoid back together, and if the cooldown went as we intended, then we'd be in fat city."

And the collaboration was. "This magnet is particularly solid and rugged—I don't know any other word for it," Smith said. "It has shown itself to be very nontemperamental. It easily charges; it easily discharges; it stays on all the time, and doesn't trip off. We expect that to be true throughout its life." In fact, when Run II begins, DZero will be the first particle detector in the world to have a radiation-transparent solenoid that provides a magnetic field as high as two Tesla.

Fly in the ointment

There is, though, a tiny "fly in the ointment," the DZero scientists cautioned. Repeated testing showed that one of the electrical joints in what is called the "chimney" isn't quite right. The chimney is the snake-like pipe connecting the solenoid deep inside the detector to the control dewar outside, which supplies the liquid helium, the liquid nitrogen and the electrical current to the system. Electrical connections in the chimney need to be tight so that any resistance is negligible.

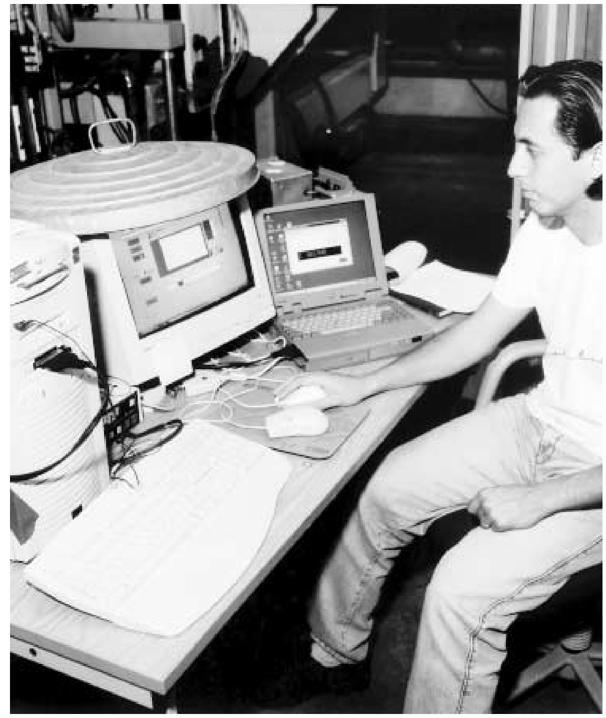
For now, the solenoid is running with the electrical joint as it is, but, as Smith remarked, "things rarely fix themselves, and generally go from bad to worse." The chimney will be opened up and the joint repaired in the next few weeks.

Meanwhile, Smith takes turns with colleagues sitting at the foot of the 5,000-ton detector in DZero's cavernous hall, watching control panels displayed on several computer screens and collecting hundreds of files on the solenoid's performance. They've capped the computer terminals with the lids of garbage cans to shield them from a bit of magnetic flux seeping out the side of the detector. ("It goofs up the monitors," one physicist said.) Behind the terminals is a television screen, where they can see the inside of the solenoid and watch the moving arm of the testing device position itself, under computer control, just where they want it to be. Called a fieldmapper, and designed and built here at Fermilab, the device measures precisely the magnetic field at desired points in the open bore of the solenoid.

Every safety precaution is taken, since the solenoid, when energized, can zap a pacemaker or suck in steel objects in its vicinity. The magnet has to be exposed to allow in the arm of the fieldmapper, but ropes and flashing lights restrict access near the magnet, and the detector hall remains locked during testing.

There will be another, more precise round of fieldmapping once the muon detectors and intercryostat detectors are back in place. The new silicon and fiber trackers will then be installed inside the solenoid.

And soon thereafter, the detector will be ready to rock. ■



Graduate student Miguel Mostafa monitors the operation of the fieldmapper. The garbage can lid sitting on the computer serves as shielding against magnet flux from the detector.

Physicist Rich Smith and Mostafa check the fieldmapper for the solenoid.

Physicists of the Home Run

The McGwire

"If a sufficient prize were given for the ball hit the farthest under baseball rules, one might recruit an Olympic-level weight man, quick as a cat, and carrying nearly 300 pounds on a near-seven-foot frame, to do the job."

~ Dr. Robert K. Adair,
The Physics of Baseball

AP Photo/John Gaps III

by Mike Perricone, Office of Public Affairs

On September 27, 1998, six-foot-five-inch, 250-pound Mark McGwire of the St. Louis Cardinals once again flexed his Olympic-class biceps and hit his 70th home run on the last day of the baseball season at Busch Stadium in St. Louis.

Until this explosive summer of "going yard," in more than 120 years of major league baseball history only two players had hit 60 or more home runs: Babe Ruth of the New York Yankees hit 60 in 1927, and Roger Maris of the Yankees hit 61 in 1961.

Sammy Sosa of the Chicago Cubs staged an electrifying chase with McGwire and closed his own phenomenal runner-up season with 66 home runs. Overshadowed by McGwire and Sosa, Ken Griffey Jr. of the Seattle Mariners hit 56 home runs and Greg Vaughn of the San Diego Padres hit 50, the first time the major leagues have seen four hitters with 50 homers.

Why?

Baseball purists finger bad pitching in an expansion year (1961 was also an expansion year) and suspect a lively or "juiced" ball.

But in reading *The Physics of Baseball* and examining Dr. Robert K. Adair's detailed analysis of the forces involved in hitting the ball (officially, 9 to 9 1/4 inches in circumference, and 5 to 5 1/4 avoirdupois ounces in weight), one factor is paramount in determining how far and how often home runs will be hit:

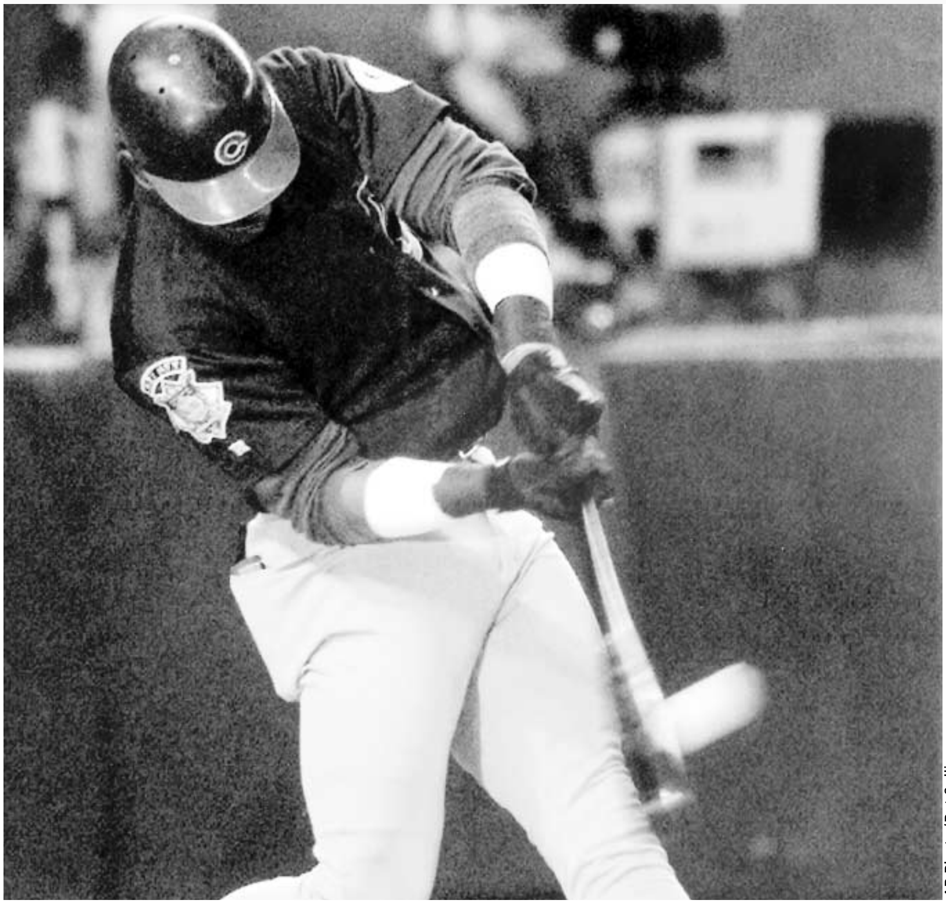
Speed—the speed of the pitch, and primarily the speed of the swing.

When contact is made, according to Adair's data, speed translates directly into distance. Their sense of the primacy of bat speed has turned McGwire and Sosa into intuitive physicists, with record-setting results.

Adair bases most of his data on an 85-mph "fastball," though a current average for a major-league fastball would be around 90 mph. The fastest pitchers, like Houston's Randy Johnson and Chicago's Kerry Wood, are routinely above 95 mph.

Adair's charts show an 85-mph pitch hit by a bat swung with a 70-mph velocity will travel about 360 feet—a long fly ball that will be caught in medium-depth center field. But that same pitch hit by a bat with an 80-mph velocity will travel about 430 feet—a home run to center field in virtually any ballpark. Adair also states that each five mph added to the speed of a pitch will add 3.5 feet to the distance it is hit; thus, a 95-mph fastball hit with an 80-mph bat velocity would travel 437 feet.

osa Transformation Equation: $Speed_{(bat)} + Speed_{(ball)} = Record_{(shattered)}$



AP Photo/Pat Sullivan

Mark McGwire (far left) delivers nearly 8,000 pounds of force with an 85-mph swing in redirecting a 90-mph fast ball from Montreal pitcher Carl Pavano for his 70th home run on September 27, 1998, at Busch Stadium in St. Louis. **Sammy Sosa**, with his upward swing, launches the ball at a 35 to 40 degree angle for his 66th home run on September 25, 1998, at the Astrodome in Houston.

Photo courtesy of Yale University

Dr. Robert K. Adair, Sterling Professor Emeritus of Physics at Yale University, was appointed Physicist to the National League by the late Bart Giamatti, a fellow long-suffering Red Sox fan. "My wife is from Boston so I don't eat if I don't cheer for the Red Sox," Adair says.

McGwire, especially, has raised the stakes.

"His bat speed—the velocity of the sweet spot—must be at least 85 mph in a good, full swing," Adair estimates from his office at Yale.

Over the years, players have gone to lighter bats to increase the speed of their swings. Ruth swung bats as heavy as 47 ounces; Maris, who weighed about 200 pounds, used a 33-ounce bat. McGwire uses a 35-ounce bat, and Sosa's is 33 ounces. Adair says that a smaller player like Sosa would compensate for McGwire's bulk with a longer swing in time and arc.

The collision between bat and ball lasts 1/1,000 of a second. In that flash of time, Adair says, as much as 8,000 pounds of force (about the weight of two Buicks) is required to redirect the motion of a 90-mph fastball heading toward home plate into a 110-mph drive toward the centerfield stands.

In that 1/1,000 of a second, McGwire and Sosa make contact with an uppercut swing that might be as much as 20 degrees off the horizontal. They'll want to meet the ball at their maximum bat velocity, which will be later in their swings than it would be for a singles hitter. They'll want to meet the ball at the sweet spot—the bat's center of percussion, where impact transfers no force or momentum to the handle. They'll achieve maximum distance by launching the ball at an angle between 35 and 40 degrees from the horizontal and the flight of the home run will not be a perfect parabola; due to air resistance, it drops at a steeper angle than it climbs.

The different contact points on the ball for a home run and a hard single up the middle are about a half-inch apart—all the more important, then, for the home-run hitter to use a lighter bat enabling him to delay his swing, improve his judgment and make more precise contact in that critical 1/1,000 of a second.

In the quarter-second required to complete a batter's swing, Adair says about 0.6 horsepower-seconds of energy (an average rate of about 2.5 horsepower) is transferred to the bat primarily through the large muscles of the thighs and torso, reaching eight horsepower or more just before impact. The arms and hands, Adair says, "serve mainly to transfer the energy of the body's rotational and transverse motions to the bat and add little energy to the bat." Of course, big biceps can efficiently transfer a big bang.

And despite the emphasis on the follow-through, it serves mostly to insure correct mechanics before contact. "Nothing one does after the bat hits the ball affects the ball-bat collision," Adair says.

The home-run hitter's sharply-angled swing increases the chances for missing the ball altogether: McGwire struck out 155 times in 1998; Sosa, 171. At the other extreme, San Diego's Tony Gwynn, a consistent contact hitter, batted .321 with 16 home runs and struck out only 18 times.

But a precision collision in that 1/1,000th of a second can produce pure magic—the scientific magic performed by the physicists of the home run. ■

They found the upsilon particle, back in 1977: Chuck Brown (foreground), with Dan Kaplan, Hans Sens, Jeff Appel and Bob Kephart lined up behind him. Atop the apparatus, from left to right, are Al Ito, Dave Hom, Ken Gray, Koji Ueno and Steve Herb.

Back to the (*b* Quark) Future

A former "all-thumbs" graduate student continues the exploration of *B* physics, two decades later.

by Daniel M. Kaplan, Department of Biological, Chemical, and Physical Sciences, Illinois Institute of Technology

When I tell people about finding the *b* quark, I half expect them to say: "I didn't know it was missing!"

That's what I would have said in 1975, when a small group of physicists from Columbia University, Fermilab, and the State University of New York at Stony Brook began building the detectors that would lead to the *b* quark's discovery.

Until the fall of 1974, only three types of quark were suspected, and many physicists were unconvinced of their physical reality. Then came the "November revolution": simultaneous announcements by groups at Stanford and Brookhaven of strong evidence for a fourth type of quark. Harvard's Shelly Glashow had been predicting the discovery for years, but few took him seriously—perhaps because he named his quark "charm."

At the time, Columbia's Leon Lederman led a group at the new National Accelerator Laboratory (now Fermilab), studying processes that produce electrons and positrons in proton-nucleus collisions. If an electron and a positron came from the decay of an unstable particle, the mass of that "parent" particle could be inferred from the momenta and angles of its "daughters."

Fresh from a year of graduate studies, I joined Lederman's group in 1975 along with a few of my Stony Brook professors. My first assignment was to help build multiwire proportional chambers, the kind of detector that had made the Brookhaven experiment so powerful. Upon accidentally cutting some of the fine wires, I was pronounced "all thumbs" and reassigned to programming the on-line computer and upgrading its software for the new detectors.

This was a high-stress job. Yet sitting in the trailer by myself, struggling with the program until the sun came up, was a new and exciting experience. We were a dozen guys on a mission out on the prairie, keeping our high-tech toys together with duct tape and aluminum foil.

We formed a complete democracy. Whether callow graduate student or senior professor, if you had a good idea, the team would consider it; if you had a bad one, they would soundly denounce it.

Our first run produced a cluster of events at about six times the proton mass, causing a flurry of excitement. But when more data showed no clustering, we chalked it up to a statistical fluctuation.

By the spring of 1977, we had an upgraded configuration that could take 1,000 times more data than our 1975 version. The key was switching to muons and antimuons, instead of electrons and positrons. Muons are just like electrons, but 200 times heavier. They decay into electrons and neutrinos in a couple of microseconds.

Being so massive, muons are little affected by the electric charges within matter. They can penetrate meters of iron, in which other particles are strongly absorbed. We could thus use shielding to absorb non-muons, allowing higher beam intensity. The cost was some loss of information about the muon direction, due to random scattering of the muons by the electric fields of atomic nuclei. We realized that beryllium shielding, though more expensive and harder to work with than iron, would minimize the muon scattering. Lederman scrounged the needed beryllium from government surplus.

After a few weeks with the new configuration, we found that the probability to produce muon-antimuon pairs peaked sharply at about 10 times the proton mass. With more data, we discerned multiple closely spaced peaks, smeared together by the muon scattering.

We were observing a new quark.

We didn't get to name our quark. Speculating about additional quark pairs, theorists had already suggested two rival naming schemes: top and bottom, or truth and beauty. Strangely, both schemes have stuck, some physicists preferring the first and some the second. With the 1995 discovery of the top quark at Fermilab, the quark roster now seems complete.

But physics, like a curious child, has a way of raising new and disturbing questions.

Photo by Reidar Hahn

Dan Kaplan in the control room of Fermilab Experiment E871, a search for CP violation.

A b-Quark Reader

For more information on BTeV, see http://www-btev.fnal.gov/btev.html.

For more on the b quark discovery, see articles by Leon Lederman in Scientific American, vol. 239, no. 4 (October 1978), p. 72; and Reviews of Modern Physics, vol. 61, p. 547 (1989) (his Nobel-prize lecture); also,

D. M. Kaplan, "The Discovery of the Upsilon Family," in History of Original Ideas and Basic Discoveries in Particle Physics, NATO ASI Series B: Physics, vol. 352, p. 359 (Plenum, New York; 1996); and

J. K. Yoh, "The Discovery of the b Quark at Fermilab in 1977: The Experiment Coordinator's Story," as well as other articles in Twenty Beautiful Years of Bottom Physics: Proceedings of the b20 Symposium, AIP Conference Proceedings 424 (American Institute of Physics, Woodbury, NY; 1998).

Many physicists now view *b*-quark decays as the key to a fundamental problem involving matter, antimatter and the very existence of the material universe. While matter and antimatter appear to be almost mirror images, the universe as a whole seems to contain almost no antimatter. And a good thing, too, since matter and antimatter annihilate into energy upon contact.

How could such an asymmetric universe have arisen? Shouldn't the Big Bang have produced equal amounts of matter and antimatter, ultimately producing a universe containing nothing but energy? How is it, then, that stars, planets and people exist at all?

We now expect *b*-quark decays to show the largest matter-antimatter asymmetry (a.k.a., CP violation; see *FermiNews*, vol. 21, no. 8) of any known phenomenon. But the expected effect is too small to account for a universe made of matter. New *b*-quark experiments are in the works, including the BTeV proposal at Fermilab on which Lederman and I are working along with fellow *b*-quark discoverers Jeff Appel and Chuck Brown. Perhaps the new experiments will reveal a larger effect, arising from mechanisms yet unknown.

As of 1998, six experiments that could yield *b*-quark breakthroughs are preparing to run: BaBar and Belle at the two e^+e^- "*B* factories" (at SLAC, and at KEK, in Japan); CLEO III at Cornell; HERA-*B* at DESY in Hamburg, Germany; and our own CDF and DZero. If the Standard Model for CP violation is correct, they will see a big effect. (Indeed, CDF already has a hint of this but with a large statistical uncertainty, as does DELPHI at LEP.)

Untangling the Standard Model's complicated predictions will take many billions of *B* decays. We hope that, by measuring *B* decays at an unprecedented rate, BTeV would make a strong contribution.

Ironically, the large Standard Model effects in beauty also could obscure a possible small (but exciting) contribution from new, unknown physics. Or the large predicted effect might be absent: perhaps *all* of CP violation is due to new physics. In either case, we might learn something new and important from CP violation and related effects in charm. Fortunately, BTeV will also be an outstanding charm experiment—but that's another story. ■

Will these students find a future in high-energy physics?

Graduate Student Blues

Prospects for basic-research jobs in physics are bleak, but at least no one's working at MacDonald's.

by Sharon Butler, Office of Public Affairs

When Fermilab's Graduate Student Association polled its membership last year for opinions on career opportunities in high-energy physics, the responses were enough to make a person weep.

One postdoc drew an analogy with a school of fish swimming up a river that has a nasty waterfall up ahead. Swimming is easy at first (as a student), but gets tougher as the fish reach turbulent water (when a student applies for his / her first postdoc). Farther up the river, as the water becomes increasingly turbulent, the fish see the dead bodies of other fish floating by (the bodies of the unsuccessful applicants). At the waterfall, the fish are beaten by the current and crushed on the rocks. A few, but just a very few, survive, and manage to pull away from the current (landing an academic position with hope of tenure). They keep on swimming, eventually reaching calmer waters upstream (tenure at last), now forgetting just how awful that waterfall was.

Of the 22 graduate students and postdocs who responded to the Graduate Student Association's survey, 15 said they didn't see a future for high-energy physics in the United States. Ten said they planned on staying in the field—although five specified they would stay *if* they could. The others said they were leaving the field because of a lack of jobs—in particular, permanent jobs.

According to Roman Czujko, who collects employment statistics for the American Institute of Physics, concern is appropriate, but despair—and analogies with dead fish—an overreaction.

The job market for high-energy physicists has been tight for more than a decade. Even in the 1980s, the number of new Ph.D.s far outflanked the number of openings in basic research.

In the early 1990s, competition for academic posts worsened. Although the number of positions in physics departments has remained relatively stable—about 400 each year, across all fields—universities were now turning out about 1,400 new Ph.D.s annually. Moreover, beginning earlier this decade, corporate downsizing brought physicists back into academics from private industry, and scientists with degrees from abroad were competing for university posts.

AIP statistics for the 1995-96 academic year (see www.aip.org/statistics) reflect the currently pessimistic assessment of opportunities in academic and government research. In particular, the proportion of new Ph.D.s accepting potentially permanent positions, as opposed to postdoc positions, more than doubled from 1993 to 1996, from roughly 20 percent to 50 percent. Almost 70 percent of those who accepted potentially permanent positions found employment in the industrial sector, compared with about 40 to 50 percent a decade ago. Many of the jobs were in areas other than physics.

As Czujko is quick to mention, these statistics do have a positive side: for those willing to consider a life outside the hallowed halls of basic research, opportunities abound. Industry clearly needs the kind of skills and knowledge that physics doctorates can offer.

In fact, Czujko says, newly minted physicists should thank their lucky stars that they are not chemists or microbiologists.

According to data posted by the American Association for the Advancement of Science, the unemployment rate for recent Ph.D. physicists is less than 2 percent, while that for

most other scientists, from mathematicians to microbiologists is over 2 percent. The median salary for physicists in private industry is $62,000, compared with $60,000 for mathematicians and $44,250 for microbiologists. Physicists are beaten out in salary only by engineers and computer scientists.

Czujko also maintains that physicists, whether they are teaching in four-year colleges or working in the private sector doing applied engineering, have high job satisfaction.

Remaining upbeat, Czujko likes to remind disheartened graduate students: "No physicist is working at MacDonald's." ■

CALENDAR

OCTOBER 16

Argonne National Lab is hosting an open house for its Math and Computer Science Division, noon – 5 p.m. in Argonne-East's Building 221. Fermilab employees are invited.

OCTOBER 23

Fermilab International Film Society presents: *Cronos* Dir: Guillermo del Toro (Mexico, 1992, 95 mins). Film at 8 p.m., Ramsey Auditorium, Wilson Hall. Admission $4. (630) 840-8000.

OCTOBER 24

Fermilab Art Series presents: *Alvin Ailey Repertory Ensemble*, $20. Performance begins at 8 p.m. Ramsey Auditorium, Wilson Hall. For tickets or more information, (630) 840-ARTS.

Prairie Seed Harvest, 10 a.m.–2 p.m. Follow on-site directional signs. Wear field clothing & gloves, bring pruning shears & paper grocery bags. Large groups, please call ahead (630) 840-3303. For rainout info, call (630) 840-3000.

NOVEMBER 3

The Medical Department will hold an immunization clinic from 11 a.m. to 1 p.m., in the ES&H training room on the ground floor, east side of Wilson Hall. Contact Mae Strobel, x3232.

ONGOING

NALWO coffee mornings, Thursdays, 10 a.m. in the Users' Center, call Selitha Raja, (630) 305–7769. In the 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.

Web site for Fermilab events:

http://www.fnal.gov/faw/events.html

LAB NOTES

Charities Program

The Charities Program has a new procedure this year. Check out the "Fermilab at Work" Web page for directions & instructions on how to properly fill out your form (http://www.fnal.gov/faw/charities/charity.html). If you have any questions or concerns, need assistance or do not have access to the Web you may request paper forms by phoning Ruby Coiley, x8365.

Winter Recreation

To stay in shape, get in shape or just have fun, check out the recreation Web page (http://fnalpubs.fnal.gov/benedept/recreation/recreation.html). Many classes and leagues are starting up.

NOTE

Because *FermiNews* is now being mailed under a bulk rate, the post office will no longer forward issues to a new address when you move. If you want to keep receiving your copies of *FermiNews*, be sure to keep your address current.

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
http://www.fnal.gov/faw/events/menus.html

Lunch Wednesday October 21

Grilled 5-Spice Pork Loin
Dilled New Potatoes
Vegetable of the Season
Peach Cake

Dinner Thursday October 22

Tart of Sundried Tomatoes, Walnuts and Cheese
Monkfish in Whiskey Sauce
Saffron Lemon Rice
Vegetable of the Season
Flambeed Crepes with Grand Marnier Sauce

Lunch Wednesday October 28

Cheese Fondue
Baby Greens in Mustard Vinaigrette
Pineapple in Hot Buttered Rum Sauce

Dinner Thursday October 29

Jack-O-Lantern Surprise
Bloody Mary Baked Mahi Mahi
Witches Hair
Booberry Tart

CLASSIFIEDS

FOR SALE

■ ’90 Chevy Lumina, good condition, 140K miles, asking $2,000 obo. Call Robin, x3377 or robin@fnal.gov.

■ ’90 Olds Cutlass Ciera, white, pwr wind / others, air, stereo / Cass, 72K $2,800. Call x5003, (630) 836-0138, or bockjoo@fnal.gov.

■ ’88 Toyota Corolla, automatic, 98K miles, new radiator, 2nd owner w/ all records, $2,800 obo. Monique, srivasta@fnal.gov.

■ ’86 VW Golf GTI, 3-dr htchbk, black, 5-sp, 133K highway miles, a / c, CD am / fm, sunroof, tint windows, looks & runs great, no rust, maint. records for last 6 yrs, $1,950 obo. Dima x3601(w), x4922(h), vavilov@fnal.gov

■ Mattresses, boxes, & recliner sofa, bockjoo@fnal.gov, x5003, (630) 836-0138.

■ 8-pc. Contemp. living room set, like new, $640 (paid $1280 2 yrs ago), Futon bed (dbl) w / wood frame, $90. Light, sturdy computer desk (white top w / steel frame), $90. Entertainment center, $45. Two lrg bookcases, kitchen table, coffee table, lrg steel storage shelves, $25-$35 ea. Small furniture, lamps, fans, $5-$20. Call Dhiman, x8569, (630) 231–4170 or dhiman@fnal.gov.

■ Jackets, Men’s leather, size 46, dark brown, “Chess King,” good condition. Women’s down jacket, XL, new, blue color. $20 ea. Phone (630) 243–1125.

■ Skis (Adult & lots of kid sizes & poles); Kenwood single CD player for a component stereo system DP840, $75 obo; 250 MB tape drive uses DC2120 tapes, $15; King size waterbed frame & headboard needs mattress, $75; Wood lathe, included are chisels & cabinet w / drawers $250; Dive equipment, Parkway BC vest $85, US divers wet suit $50; 2 VCR’s $50 ea; 1 small Sub-Zero refrigerator $95; Call Terry, x4572 or skweres@fnal.gov.

■ Cat cage, wire, 2 shelf. size 3′width x 2′deep x 3′ high. One month old. Paid $190 sell for $150. Contact worland@fnal.gov or x3156.

■ Desk, new complete office workcenter, great value, asking only $200, worth much more. Call for details (630) 717-5181.

■ Tons of computer software (shareware & boxed titles), would like to sell in bulk, call for details, Terry, x4572 or skweres@fnal.gov.

■ Antiques! Beautiful, quality pieces including: oil lamps (prices vary); set-4 oak bentwood chairs ($225); mahogany rushed chair ($160); oval drop leaf table ($175); oak stool w / moving parts ($150); beveled mirror ($75); pine 1 / 2 table ($40); pine stool ($45); shelf ($65); sickle ($40); Honduran mahogany spindle table (needs restoration, new Honduran mahogany wood incld. for restoration) ($75); 1987 Ed. “June” Precious Moments ($50). Call (630) 717–5181 if seriously interested.

■ House, W. Aurora, near Aurora U., 2 bdrm ranch, central air, neutral decor, large living room, oak cabinets in kitchen, finished basement w / possible 3rd bdrm, 2 baths, large deck w / patio, privacy fence around nice sized yard. Asking $117,500. Call (630) 897–9596.

RENT

■ Apartment for sublet, West Chicago, spacious 2 bdrm (870 sq. ft.) on 3rd floor, 8 min. from lab. Available Dec 1-Mar 31 for $648 / mo (after 10% discount on full rent). Lease renewable afterwards at full rent. Call Dhiman, x8569, 231-4170 or dhiman@fnal.gov.

BENEFIT NOTE

Dental Claim Forms

The traditional Dental Plan claim forms with the new claims office address are available from the Benefits Office, 15WHNW. You can continue to use the old form, but you will have to remember to mail it to the new address: CIGNA Healthcare Service Center, P.O. Box 15558, Wilmington, DE 19850-5558.

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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.

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