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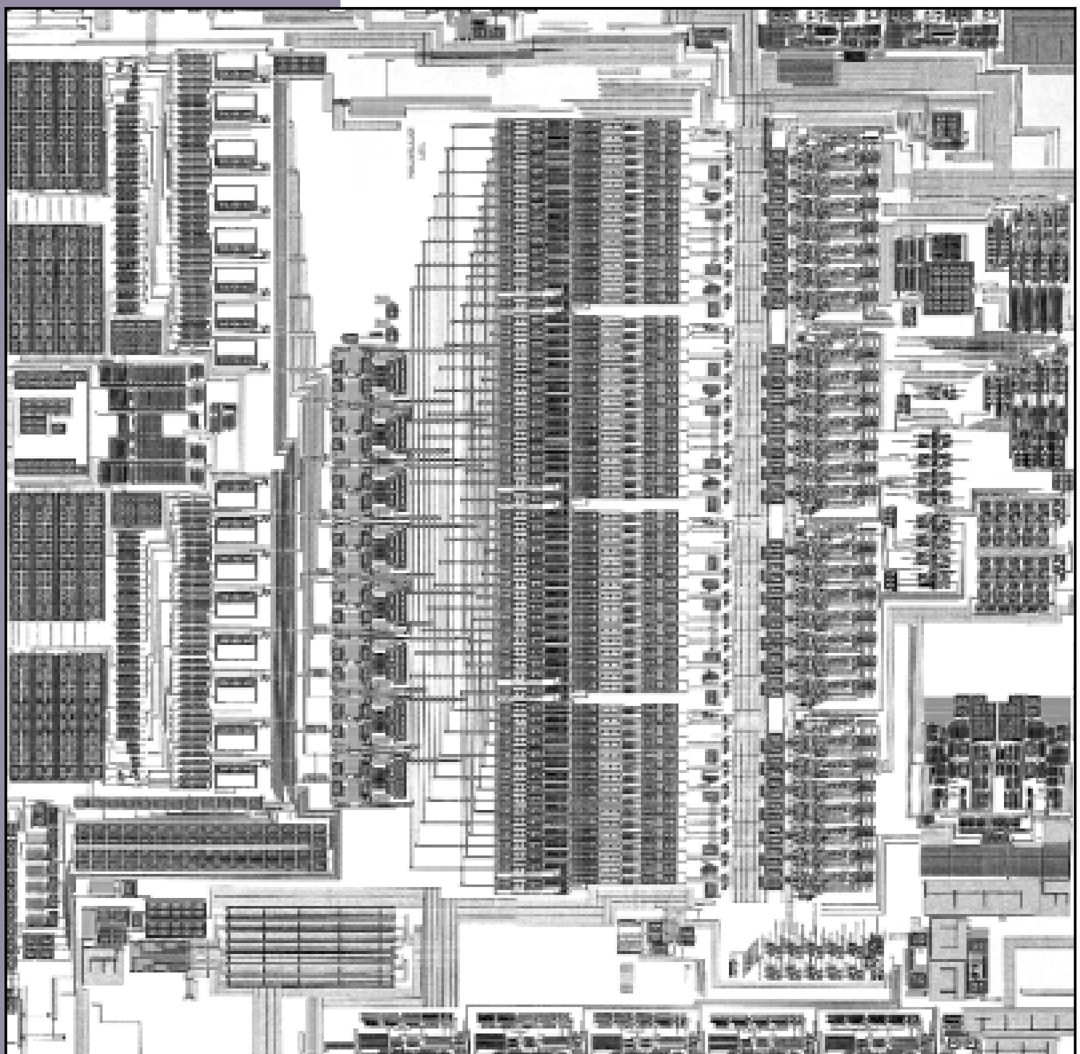

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Engineering FERMILAB

At its best, a SYNERGY occurs between PHYSICS and ENGINEERING

Saying that engineering contributes to physics is like saying that water can be helpful to fish. Without engineering, physics would not be physics. What makes physics a science, and not mere speculation about how the world might work, is experiment; and to make an experiment takes engineering.

Before Galileo could drop anything, somebody had to build that tower. The nucleus did not appear to Rutherford in a vision. The top quark was only a theorist's vaporous construct until the Tevatron made it, and CDF and DZero saw it. Physicists need tools. Engineers design and build them.

And, no field of physics needs tools like high-energy physics needs tools. You can't make a quark with your bare hands, and you can't see neutrinos with your eyeballs. (You can barely see neutrinos anyway, even with the fanciest of fancy engineering.) It's a truism that to see the smallest objects, it takes the biggest tools, and particle accelerators and detectors are tools on the grand scale. If physicists need engineers, high-energy physicists *really* need engineers.

For high-energy physics, engineering is destiny. It's simple: the kind of physics you can do depends on the kind of tools you can build. Right now, not only at Fermilab but throughout the worldwide particle physics community, physicists and engineers are trying to understand and create the next generation of tools for the next generation of physics. What can we build? What will we discover? There's no separating those questions.

Also: What will it cost? When an interviewer asked Dan Olis, a DZero engineer, if he ever encounters engineering problems that make him throw up his hands and give up, Olis looked puzzled.

"If you are an engineer," he said, "you feel there must be a solution to a given problem. Hopefully, you can find the simplest, most elegant and cheapest one."

Of course, it's a two-way street. If physics needs engineering, engineering needs physics too. The more that physicists learn about the physics of superconductivity, the better the magnets that engineers can design for the next generation of accelerators. Quantum mechanics put the "E" —at least the first one—in Double E. When Harry Carter and the Blue Man Group at CDF lift 100 tons of steel 40 feet in the air, you can bet that Newtonian mechanics guides their every move. Engineering is all about physics, and vice versa.

Engineers who find happiness at a physics lab seem to be a special breed.

"The engineers who stay with us at Fermilab," Director Mike Witherell said recently, "are those who enjoy the challenges, the atmosphere, and the environment of similarly motivated and imaginative people. The engineers at our laboratory enjoy being part of one of the world's great scientific enterprises."

At its best, a synergy occurs between physics and engineering, and between physicists and engineers. Bob DeMaat, a CDF engineer, put it this way:

"You need a combination of engineers with an understanding of the physics of the experiment, and physicists who understand the engineering. They have a feeling for the technology that will work."

On April 19, Fermilab's engineers came together in the Wilson Hall atrium for the family portrait on these pages. This issue of FermiNews is devoted to them. To do the subject justice would take a book. In these few pages, we tell a few of the stories of the engineering, and the engineers, that make Fermilab work.

Photo by Reidar Hahn

Some of the more than 200 engineers working at Fermilab.

Engineering RUN II

*“The **SCIENTIST** describes what is; the **ENGINEER** creates what never was.”*

—Theodor von Kármán

by Judy Jackson

The pyramids. The Eiffel Tower. The Brooklyn Bridge. The Empire State Building. When it comes to engineering marvels, Run II at the Tevatron is up there with the Wonders of the World.

Until now, no one has ever built anything like this creature of steel, plastic, fiber, helium, superconductor, glue, silicon, scintillator, water, electricity, gas; this assemblage of microcircuits, magnets, lasers, cables, valves, pumps, chillers, controls, tanks, pipelines, vacuum systems, phototubes, wave shifters, light pipes, targets, electronics, cooling, heating, input and readout, data acquisition and analysis; this engineering phenomenon called Run II.

Fermilab engineers and their colleagues at laboratories and universities around the world have worked for nearly a decade to create accelerators and detectors that—until now—never were, so that Fermilab scientists can search for what is, at the smallest scale human beings have ever seen. Run II at the Tevatron represents not only the start of a new scientific quest, but also the culmination of an almost unimaginable engineering effort.

Run II embodies the solutions to thousands of engineering challenges of extraordinary variety and scope. To build Run II, engineers have designed electronic chips with channels of circuitry so tiny they make a human hair look huge; and they have hoisted hundred-ton hunks of steel high in the air. To raise the Tevatron’s energy, they have lowered its operating temperature and in the process doubled the size of the world’s largest helium liquefier. They have calculated, tested, measured, recalculated and retested. They have gone to Plan B, and Plan C, and sometimes back to Plan A. Each engineering problem solved is a story: the choice of one material over another; the discovery of exactly the right glue to hold a fiber bundle in place; the formation of a rigging crew; the design of a magnet lattice to cool a stack of antiprotons; the bookkeeping to track hundreds of components as they come to life across the globe; the art of fitting tab A into slot B as the components converge in a 5,000-ton detector.

It would take a dozen issues of FermiNews to tell all the stories of the engineering of Run II. The case studies that follow give a flavor of what it takes to build what never was, the accelerators and detectors for the physics that is, at the energy frontier.

Photo by Fred Ullrich

Working as the Blue Man Group, John Voirin, Wayne Shaddix, Craig Olson and Harry Carter brought hundreds of components together to create a functioning CDF detector.

Ray Yarema, Particle Physics Division

At the heart of the new CDF and DZero detectors, the latest generation of silicon vertex detectors will track trillions of high-energy proton-antiproton collisions, searching for the displaced “v”s that mark the decays of b quarks. Mounted on the detectors’ silicon strips are thousands of new-generation electronic chips that record and read out the data for each collision. Fermilab engineer Ray Yarema led the design of the Run II SVX chips at Fermilab.

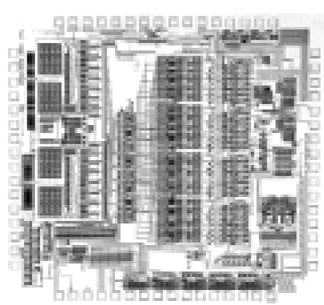
“Run II presented designers with many more collisions per second to record and read out,” Yarema said. “The challenge was to design a chip that would operate at a much higher collision frequency.”

Then, halfway through the chip design process, CDF presented Yarema with still another challenge.

“Rather than separating signal acquisition from data readout operations, CDF wanted a chip that would do both simultaneously,” Yarema said. “That was a serious problem because the on-chip digitization, data compression and readout functions would generate noise that was picked up by the very sensitive analog parts of this chip.”

Yarema’s team came up with a new idea. They plated the back side of this chip and used it as a power supply ground connection to reduce the noise problem.

Each chip has 128 channels, each one about 42 microns wide. For comparison, a human hair has a width of about 75 microns. Yet, said Yarema, the microscopic dimensions are not the only thing that made the process a challenge.



Cover photo: A full custom charge-integrator-encoder integrated circuit chip. Actual size: about 0.2 inches square.

“One of the most difficult things in chip design is defining what needs to be done,” he said. “Expectations are often too high. Part of the process is defining the achievable, then trying to do it. It takes time to define the problem you are trying to solve.”

Harry Carter, CDF

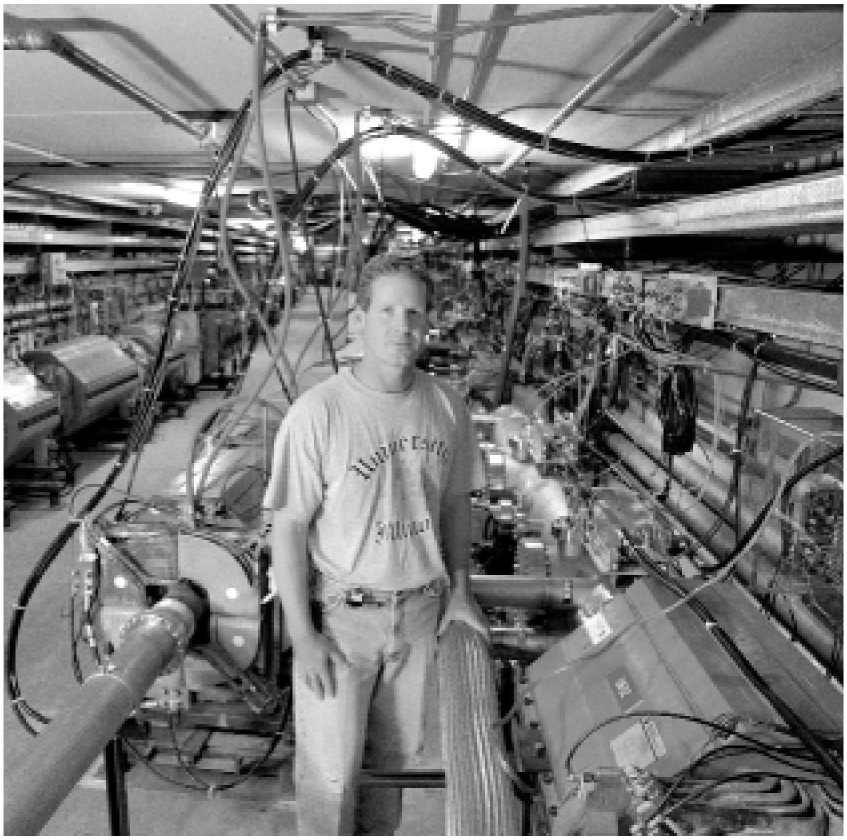
While Yarema measured his problems in microns, Fermilab engineer Harry Carter calculated his in tons. As engineering leader of the “I and I” group responsible for mechanical infrastructure and installation of CDF components, one of Carter’s first jobs was to lift a 100-ton chunk of steel muon shielding and hang it from the ceiling of CDF’s collision hall.

“It was like hanging a locomotive from the ceiling,” Carter said.

Carter and his team used a gantry to raise the steel 39 feet in the air, where it swung back and forth a bit before attachment to the ceiling.

“‘Oh,’ the riggers told me, ‘that’s what we call the gantry dance,’” Carter said. “It impressed even me.”

“CDF’s an excellent detector,” Carter said. “It will take a little time to get it working the way we want, but we all feel confident that we will get there.”



Photos by Reidar Hahn

Scientist Dave McGinnis in the reconfigured Antiproton Source.

Dave McGinnis and Ralph Pasquinelli, Beams Division

When CDF gets there, so will many more particle collisions than the Tevatron has ever delivered before. The keys to the increased collision rate are antiprotons.

"The challenge is to make more and better antiprotons for Run II," said Fermilab scientist Dave McGinnis, head of the Pbar Source. "The point of the whole Main Injector upgrade was to make more antiprotons. Okay, they made it work. Now it's up to us to handle the increased flux."

To do that, McGinnis and his team, in partnership with Fermilab engineer Ralph Pasquinelli and the Stochastic Cooling Group, overhauled the pbar cooling, the complex system that creates a beam of antiprotons all moving in the same direction with the same momentum, in the pbar storage ring.

Fermilab engineer Ralph Pasquinelli in the underground enclosures for the laser light link that helps cool antiprotons.

"In the pbar source," McGinnis said, "we use stochastic cooling, not electron cooling. Electron cooling is like putting a cold cup of coffee next to a hot cup of coffee to cool it off. Stochastic cooling is like taking green paint and separating it into blue paint and yellow paint. You have to talk to each particle individually. 'Hello? Where are you? If you're not in the right place, would you please go to the right place immediately?' The more particles you have, the faster you have to talk."

Pasquinelli echoed the need for speed.

"We had to do faster pbar cooling. The flux of pbars is up, so we had to take the cycle time from 2.4 seconds to 1.5 seconds. We had to get to cooled beam in 1.5 seconds."

To do that, McGinnis and Pasquinelli reconfigured the lattice, or arrangement of magnets and other components in the pbar storage ring, adding new diagnostics, beam position monitors and other instruments. They installed a free-space laser to transmit signals to the circulating antiprotons. Now they are working on improving the ability to stack antiprotons for injection.

"Our goal," Pasquinelli said, "is to reach 15 to 20 milliamps per hour stacking rate. The old Run I record was seven milliamps per hour. Both Dave and I hope to break that record before the end of the summer."

It won't be simple.

"Running a pbar collider is a five-ring circus," McGinnis said. "There is an art and craft to handling pbars. If you are using protons, you can always get more; but when you are dealing with pbars you have to be careful. Pbars are a precious commodity."

Andy Stefanik, DZero

At DZero, space is a precious commodity.

“Integration is the art of fitting what has to fit into the space available,” said Fermilab engineer Andy Stefanik, who had the challenge of making the DZero muon system fit together—and of fitting it into the collision hall. “We did an incredible amount of surveying and measuring.”

To roll into the collision hall, the detector had to fit under a concrete lintel beam separating it from the assembly hall.

“Early on,” Stefanik said, “the project manager told me that the gauge we would use to fit the detector into its space in the collision hall would be my finger. If it hadn’t made it, I would have been up there chipping concrete.”

Stefanik’s plans left a small but non-zero margin for error, and the detector made it under the lintel.

“You can afford to take more risk if you have a back-up plan. If not, you have to be more conservative,” Stefanik said. “If the detector had not fit into the collision hall, it would have been a showstopper.”

Photo by Fred Ullrich

Andy Stefanik had to fit the 3-layer 430-ton forward muon system into the collision hall—and into the detector.

Bob DeMaat, CDF

While Stefanik struggled with the mechanical fit at DZero, Fermilab engineer Bob DeMaat was trying to make everything come together electronically at CDF.

“The electronics at CDF were designed and built by people at institutions located throughout the world,” DeMaat said. “The challenge is to coordinate their work and make sure that it will all function together. The first question is, Will a subsystem’s operation be hazardous to the health of the experiment? It’s one thing to design something that works as an island, and something else to design it for electrically quiet operation that won’t interfere with other components. One rule is that no subsystem is allowed to drive currents through the steel of the detector. Other subsystems are sensitive to that.”

Questions of electrical distance, of cable length, also come into play, DeMaat said. In Run II, many more electronics systems are mounted on the detector itself, with more channels and more chips. What will be located on the detector, and what can run at a distance? And what will moving the detector from the assembly area to the collision hall do to the carefully configured electronics?

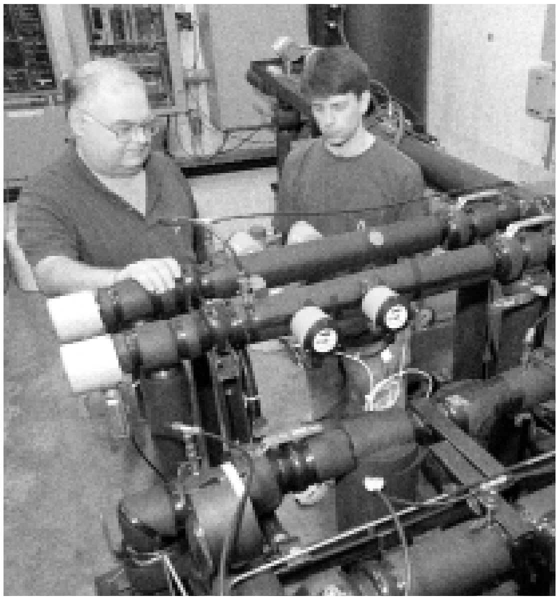
“The vast majority of the electronics made the move without a problem,” DeMaat said.

He values the interaction between the physics goals of the experiment and the technology that makes it work.

“The partnership between physicists and engineers is critical,” DeMaat said. “There are physicists who dabble in engineering. But there are also physicists who like engineering and who are really good at it. They are invaluable. You need a combination of engineers with an understanding of the physics of the experiment and physicists who understand the engineering. They have a feeling for the technology that will work.”

Photo courtesy DZero

It’s round, it’s firm, it’s fully packed. There is no room to spare in the inner recesses of the DZero detector.



Fermilab physicist Bill Cooper and engineer Dan Olis with the chiller that keeps DZero's silicon vertex detector at –10°C.

Bill Cooper and Dan Olis, DZero

At DZero, Bill Cooper is a physicist who likes engineering, working in partnership with Dan Olis, an engineer who has his eye on the physics.

"There's a tight linkage between the engineers and the experiment's physicists," Olis said. "It would be a mistake not to have constant communication. Otherwise, you could be going down a primrose path."

Cooper and Olis have concentrated their efforts at the core of the DZero detector.

Heat from the operation of readout chips in the silicon microstrip detector raises the temperature of the silicon, which is designed to operate at a temperature of below zero degrees centigrade. Cooper and his team designed and built a coolant system that circulates a –10°C. ethylene glycol and water mixture through the hollow beryllium framework of DZero's silicon vertex detector. To avoid the possibility of coolant leaking onto the silicon system, the coolant is kept below atmospheric pressure. The coolant circulation is designed to use a minimum of controls, relying instead on the physics of the beryllium passages to determine pressure and heat transfer.

"The sizing of the passages was critical," Cooper said. "DZero has just two controls on the silicon cooling system. Other than that, control is achieved through the physics of fluid and thermodynamics."

Because it is hard to seal off the cold SVX, frost could form on the cables and other components. To prevent frost build-up, Olis designed a system that uses a compressor to provide a continuous flow of 50 cubic feet per minute of dry air, with a back-up mechanism in case the compressor fails.

"If you are an engineer," Olis said, "you feel there must be a solution to a given problem. Hopefully, you can find the simplest, most elegant and cheapest one. If that doesn't work, you look for another approach."

Maurice Ball, Beams Division

Fermilab engineer Maurice Ball took another approach to cooling, optimizing the low-conductivity water systems that cool magnets in the Main Injector and Tevatron. He and his team wanted to make sure that the operators in the accelerator's Main Control Room would always know what the critical water systems were doing.

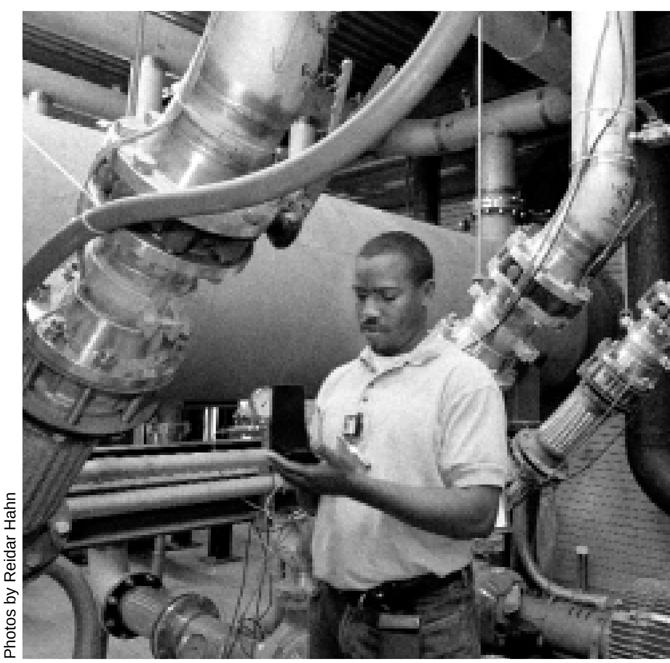
"The goal is for the water system to work with increased reliability and improved monitoring for the MCR operators," Ball explained. "The operators let me know what they wanted, so I could design a system for them. The last thing we want operators to have to worry about is water."

Thanks to new flow controls, a new temperature control system, new pressure and flow sensors and new wiring, they shouldn't have to worry.

Ball is so thoroughly immersed in water problems, he says, that colleagues wonder if he dreams of low-conductivity water at night. He and his crew have nearly completed the new Tevatron system, and he is eager for full-scale collider operations at the accelerator.

"I just like to watch it hum," Ball said.

Photos by Reidar Hahn



Fermilab engineer Maurice Ball, shown here in the Main Injector pump room, believes water problems are the last thing accelerator operators should have to worry about.

Photo by Jenny Mullins

Jay Theilacker inspecting cryogenic equipment.

Jay Theilacker, Beams Division

In Collider Run II, the Tevatron will be humming at the highest energy it has ever achieved, 1.96 trillion electron volts, in contrast to Run I’s 1.8 TeV. The energy went up because the temperature went down.

“Superconducting magnets perform better at lower temperatures,” said Fermilab Engineer Jay Theilacker, head of the Beams Divisions Cryogenics Department. “You can get the best performance out of every magnet by lowering the temperature as much as possible. To do that, you lower the pressure in the two-phase system, to make the helium boil at a lower temperature.”

Lowering the pressure meant developing new technology in the form of a centrifugal helium co-compressor, designed in partnership with a Japanese firm. During the Tevatron’s engineering run in Fall 2000, “everything ran well,” Theilacker said. “So far in Run II, the temperatures are lower and the energy is higher.”

To meet the new cooling demands, Theilacker’s group upgraded Fermilab’s Central Helium Liquefier. Originally designed to be used as a back-up facility, CHL has become essential to Fermilab’s accelerator operations.

“We essentially built a second CHL,” Theilacker said. “We built Cold Box Two, identical to the original Cold Box One, but with bigger turbines for more capacity. Then we replaced the turbines in Cold Box One, to regain redundancy. We upgraded the pressure vessels and relief valves to run CHL at higher pressure for more capacity and greater efficiency. Either one of our cold boxes alone is easily the world’s largest helium liquefier. It took the dedication of the entire Cryogenic Department for over a decade to get to where we are today.”

To build Run II and make it work, engineers at Fermilab and around the world have solved thousands of problems like the ones in these case studies. In doing so, they have created something extraordinary: the most powerful opportunity for discovery in particle physics in the world.

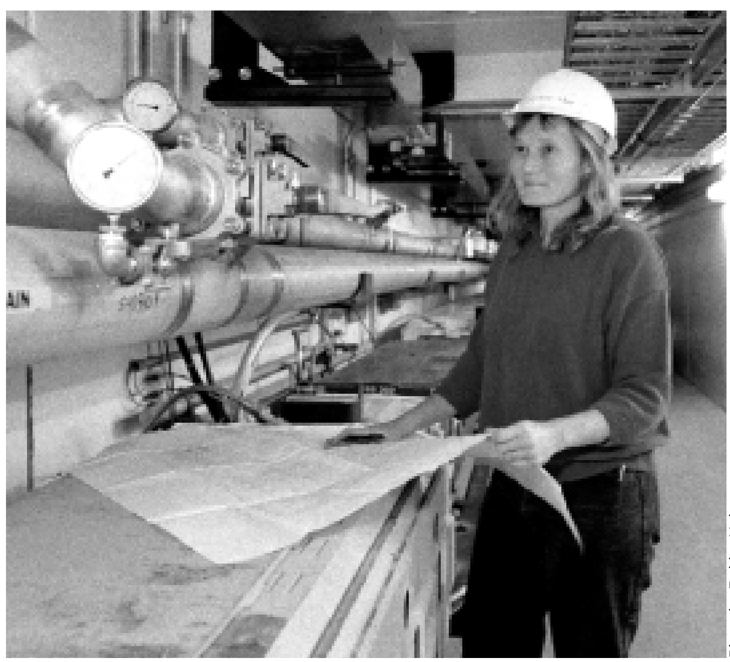


Photo by Reidar Hahn

Beams Division engineer Christine Ader developed motorized stands for stochastic cooling tanks for the Recycler Ring. “I couldn’t just go to ‘Stands ‘R’ Us’ and buy them,” she said. So Ader and colleagues designed and built the motorized stands at Fermilab.

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Engineering THE WORKPLACE


Photo by Reidar Hahn

Elaine McCluskey, lead engineer of the Wilson Hall Safety Improvements Project.

by Mike Perricone

"Physics on the prairie" calls up images of sweeping natural vistas, of high skies, grasslands and wildlife.

Physicists on the prairie, however, tend to do their best work indoors, with plenty of heat, water and electrical outlets. It all starts with a building, and buildings are just the start of the responsibilities for Fermilab's Facilities Engineering Services Section.

If the infrastructure—the pipes, the plumbing, the power cables, the heating and cooling, the roads and buildings, the intricate pond network—on the frontier of high-energy physics functions smoothly in Run II, it will mean FESS has done its job; if there's a glitch anywhere, FESS will be on the job. Immediately, if not sooner.

"If a call goes out because of a problem at 2 a.m., our people are right there. No questions asked," says David Nevin, head of the nearly 150 engineers, architects, technicians, carpenters, janitors and support people staffing FESS.

FESS sees its mission as no less than the safeguarding of Fermilab science.

"It is absolutely critical that the experiments remain 'up,' that they're able to collect good information and capture good interactions," Nevin says. "Any time an experiment cannot perform that task, billions of pieces of valuable information are being lost. That's it—they're gone.

"Our job, as far as any function of infrastructure, is to ensure that losses of information are at an absolute minimum. We know we can't achieve zero losses, but our mission is to drive that number as close to zero as possible."

While the detectors and the accelerator complex have been virtually reinvented for Run II, much of the laboratory's infrastructure has served for three decades and is reaching its design limit. At that stage, anything can happen, and often does. Some of the major FESS projects to make aging infrastructure serve frontier physics:

- **Wilson Hall Safety Improvements Project:** This three-year, $18-million revamping of the lab's signature building was occasioned in part by a chunk of loose concrete that broke one of the cafeteria windows in 1993. Under Elaine McCluskey's direction, the effort has replaced improperly-installed joints in the crossovers that tie Wilson Hall's towers together; installed new skylights, and new safety glass in the north and south faces; installed new plumbing. The final phase, reworking the building's front entrance, will be completed this summer.

- **Utilities Incentive Program:** A Federal program allows commercial utilities—in this case, ComEd and NICOR—to provide the lab with new facilities and receive payment through resulting savings in energy costs. The first UIP project, in 1999, provided a new chiller for the Central Utility Building. ComEd invested $3.5 million, and the lab's current annual saving in energy cost is $900,000. By the end of FY04, Fermilab will be finished repaying ComEd out of those annual savings. In FY00 and FY01, UIP contracts totaling $52 million will save about $6.5 million in annual energy costs.
- **New feeder cables:** Fermilab has 15 miles of power cable above ground—and another 100 miles of power cable below ground, taking in 345,000 watts of electricity from ComEd and feeding it around the site. Nevin has a chart on his wall noting feeder cable failures with red dots; he says "it started to look like a bad case of measles." In 2000, there were 23 feeder cable failures—and the lab still hadn't begun a full-out experimental run. With UIP help, FESS has begun replacing old cables to instill a new level of reliability instead of just trying to keep up with failures. The result: just two feeder cable failures in 2001 by mid-April with Run II underway.
- **New power substation:** Part of the Main Injector Project completed in 1999, the new substation allows splitting the load between two main feeders from ComEd. The flexibility adds significant reliability; a failure in a main feeder now affects only the facilities fed by that substation, and power can be "backfed" from the other substation.

FESS does much of its work behind the scenes. Some equipment had to be serviced before Run II could start, because it wouldn't be accessible once the accelerators were running. The run couldn't begin without all power and water utilities fully operating. The ponds, circulating the cooling water for magnets and electronic components around the lab, must be maintained at the proper levels, temperatures and evaporation rates.

FESS makes it all work. Turn on the lights, set the thermostat, and have some fresh coffee. Physics on the prairie feels just like home.

On the Web: www-fess.fnal.gov

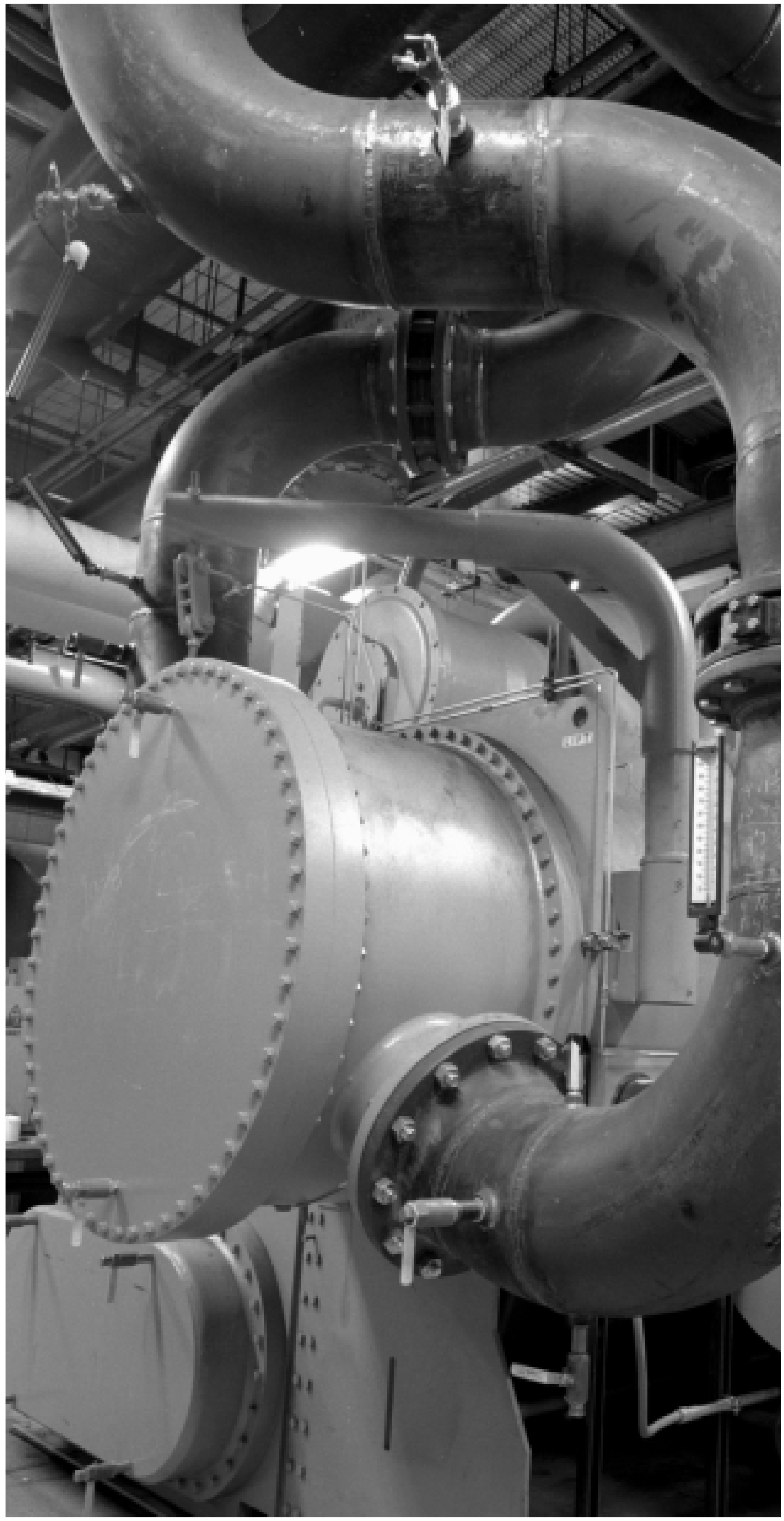


Photo by Fred Ullrich

Under the Utilities Incentive Plan, Commonwealth Edison installed state-of-the-art equipment like this 1,400-ton chiller in the Central Utility Building. The new chiller uses about half the energy of the machinery it replaced.

Engineering NEUTRINOS

The NuMI project includes several tunnels and underground halls. Contract engineer John Sollo stands in front of the tunnel boring machine that will be used for about 900 meters of tunnel excavation.

by Kurt Riesselmann

Wet, dirty and deep underground: a perfect place for a particle experiment. Protected from light and cosmic particles, two underground experiments at Fermilab will catch the particles that usually traverse the earth without leaving a track: neutrinos.

Engineering is key to the success of these unique experiments, MiniBooNE and NuMI/MINOS. Digging tunnels, installing infrastructure, assembling detectors, building electronics and aligning particle beams takes years of planning, construction and commissioning, often to unprecedented levels of precision.

Photos by Reidar Hahn

Chris Laughton, Fermilab's engineering expert on underground excavation.

Underground construction

The Neutrinos at the Main Injector project at Fermilab features about 1,200 meters of tunnels, three access shafts and a couple of underground halls as big as small cathedrals. The NuMI construction started in March 2000, and scientists will take the first neutrino data in 2004.

Working with physicists and construction companies, Tom Lackowski oversees the engineering of the NuMI project. From the early planning stages of this multi-million-dollar project, he has coordinated the engineering work, making sure that project specifications are maintained throughout construction. He must also accommodate physicists' requests for design changes.

"Civil construction is usually 'way ahead of the physics," said Lackowski. "It would be nice to have all the planning done before construction starts. But it's just not realistic. Technologies are still being developed while the construction of the facilities is going on."

Precision alignment

Scientists will use the NuMI beam line at Fermilab to create a neutrino beam and send it 735 kilometers through the earth to the 8-meter-wide MINOS detector, located in a former iron mine in Soudan, Minnesota.

Like many other Fermilab enterprises, the NuMI project is at the forefront of technological feasibility. Physicists require the center of the neutrino beam to hit the core of the MINOS detector within 12 meters. To hit their target, engineers must determine the absolute global positions of the beam line at Fermilab and the detector in Minnesota to within a meter. Then they must align all components of the 300-meter-long beamline at Fermilab within a quarter of a millimeter—less than a micron per meter—to achieve a sufficiently precise aim.

Wesley Smart (left) and Virgil Bocean work with a GPS receiver at a Fermilab geodetic marker whose global position is known to better than one centimeter. It plays a crucial role in the global alignment of the NuMI beam line.

"This kind of project has never been done before," said Virgil Bocean, a geodetic engineer working on the project. He is in charge of building the geodetic network necessary to achieve the required alignment.

"The original specifications and tolerances came from the physicists," said Bocean. "Based on their physics simulations, they told us the technical parameters they would like to achieve. We reviewed their numbers in conjunction with our surveying capabilities and told them what could be done."

Precisely determining the absolute global position of an underground object, hidden from stars and satellites, is a challenging task. Not to mention that the earth changes its shape a few meters every day because of gravitational forces.

"We used all kinds of methods that are not commonly used," said Bocean. "At Soudan, for example, we couldn't see the bottom of the shaft from the top. Going up and down in the elevator, we used a gyroscope-accelerometer-based inertial navigation system that is normally used in helicopters to transfer coordinates. We lost less than half a meter in precision in all three directions along the 710-meter-deep shaft. Because we determined the surface positions to better than one centimeter, we still met the required tolerances for absolute positioning."

DETECTOR DESIGN

Since neutrinos barely interact with matter, scientists increase the likelihood of observing one of these elusive particles by building extremely massive detectors. The MINOS experiment features a 10,000-ton detector made of steel and scintillating fiber. In contrast, the scientists of the MiniBooNE experiment at Fermilab will use a 12-meter-diameter sphere filled with one million liters of mineral oil in which the rare collision of a neutrino with a nucleus creates a tiny light flash. Inside the tank more than one thousand light-sensitive devices, called photomultipliers, will record the flashes and transmit electrical signals to the data acquisition system.

Presently, the MiniBooNE collaboration is working on the installation of the devices, usually referred to as PMTs. Engineer Bill Sands, of Princeton University, designed the PMT support structure.

"There are a thousand ways to do it," said Sands. "I used three criteria: structural integrity, ease of fabrication and ease of assembly. Simplicity, of course, is always the keystone."

Photos by Reidar Hahn

A spherical layer with 1,500 photosensors, mounted on both sides, is placed inside the underground tank of the MiniBooNE experiment.

“It would be nice to have ALL THE PLANNING done BEFORE construction starts. But it’s just NOT REALISTIC.”

—Tom Lackowski

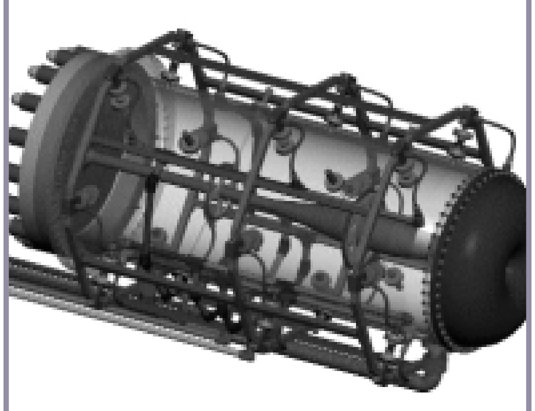
BEAM FOCUSING

To observe a maximum number of neutrino interactions, Fermilab scientists rely on intense man-made neutrino beams. Smashing protons into a target, physicists create a shower of secondary particles that decay and produce neutrinos. The problem: relatively few secondary particles leave the target in the forward direction, the path of the incoming protons.

Physicists use a focusing device, called a horn, to harvest a larger fraction of secondary particles, forcing them into a forward direction. The horn produces a finely tuned magnetic force field that creates the right strength of force depending on the angle in which secondary particles leave the target.

Both neutrino experiments will use horns. For the MiniBooNE experiment, engineers designed a two-meter-long horn that takes a pulsed current of 170,000 amps to create an appropriate magnetic field 5 times per second, exactly matching the frequency at which packages of protons hit the target.

MiniBooNE horn with cooling system



Graphic: Bartoszek Engineering

“The engineering of the focusing horn is the whole show,” said Joel Misek, lead engineer of the MiniBooNE beam line. “Building the beam line facility, designing adjustable stands and installing magnets is just our normal bread and butter.”

The MiniBooNE horn is expected to last about a year, delivering 100 million pulses. The strong electrical currents forced through the horn require the design of special power supplies and connectors.

“The horn is like a huge coaxial cable operated in pulsed mode,” said Larry Bartoszek, who engineers the mechanical design of the horn. “Fatigue is a big concern.”

Bartoszek worked at Fermilab as a mechanical engineer from 1983 to 1993 before he started his own consulting business. As a contractor, he continues to work on projects in particle physics around the world.

“The usual commercial work is not as interesting to me,” he said. “In those jobs you don’t do things that are way out on a limb.”

Deep underground, to new heights of precision, or out on a limb—Fermilab engineers go wherever neutrino physics takes them.

On the Web:

Neutrino physics:
www.fnal.gov/pub/inquiring/physics/neutrino/

MiniBooNE experiment:
www-boone.fnal.gov

MiniBoone horn:
www.bartoszekeng.com/mboone/mboone.htm

NuMI construction:
www-fess.fnal.gov/engineering/NuMI/start.htm

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Engineering THE FUTURE

by Kurt Riesselmann

When better accelerators are built, engineers will build them.

Great engineering is at the heart of today's most powerful accelerators, and it will have a central role in creating the physics machines of tomorrow.

BUILDING THE LHC

Fermilab heads the U.S. contribution to the Large Hadron Collider at CERN, which will become the world's most powerful particle accelerator in 2006. Under construction in Geneva, Switzerland, it will incorporate the latest generation of advanced superconducting magnets. Fermilab, recognized for its expertise in magnet R&D, is building 16 of the most complex of them.

Jim Kerby and Tom Nichol, mechanical engineers, manage the design and production of the magnets and cryogenic infrastructure. Each magnet is six meters long and forty centimeters in diameter. Electric currents of 12,000 amperes, which flow through superconducting wires, create magnetic field strengths of eight Tesla, one of the highest peak fields ever achieved in the world.

"We are constantly asked to do things that not many people have done before – if at all," Kerby said. "And we are asked to do it fast and cheap."

Photo by Reidar Hahn

It took extensive modeling and prototyping for engineers Yuenian Huang, Marsha Schmidt and many other Technical Division experts to produce the first reliable superconducting quadrupole magnet for the LHC.

R&D FOR SUPERCONDUCTING MAGNETS

The coils of the LHC magnets are made of niobium-titanium, a superconducting material that is approaching its limits. To build stronger magnets for future proton accelerators, scientists need to achieve higher current densities. Engineers at Fermilab, including Emanuela Barzi, work on a possible solution: coils made of niobium-3-tin, which could lead to magnetic fields of 12 Tesla or more.

Photo by Jenny Mullins

Emanuela Barzi

While Barzi tests and develops the super-conducting wire, Yuri Terechkine works on the fabrication of the coils.

"This new material requires special heat treatment," Terechkine said. "Afterward, the material is very brittle."

Testing the first Ni_3SN magnet will take place next month.

Another group of engineers works on an alternative approach. Instead of pursuing high-field magnet research, it tries to develop an inexpensive type of low-field magnet with field strength of about 2 Tesla.

Photo by Reidar Hahn

Jeff Sims, John Reid, Yuri Terechkine and Jocelyn Monroe received Employee Recognition Awards for their work on future colliders.

"Barry Norris and I work on the cooling systems of the initial design," said Arkadiy Klebaner, a cryogenic engineer. "The magnet cooling scheme is entirely different from the design of the Tevatron and the LHC."

Norris, an electrical engineer, leads a group of 12 people in the Beams Division. About five years ago, his group started work on cooling systems for future accelerators.

"The Technical Division has a lot of people working on magnet designs," Norris said. "We are the system designers. Any system needs to be automated, instrumented and controlled. And it all needs to be done in a way that fits with existing systems."

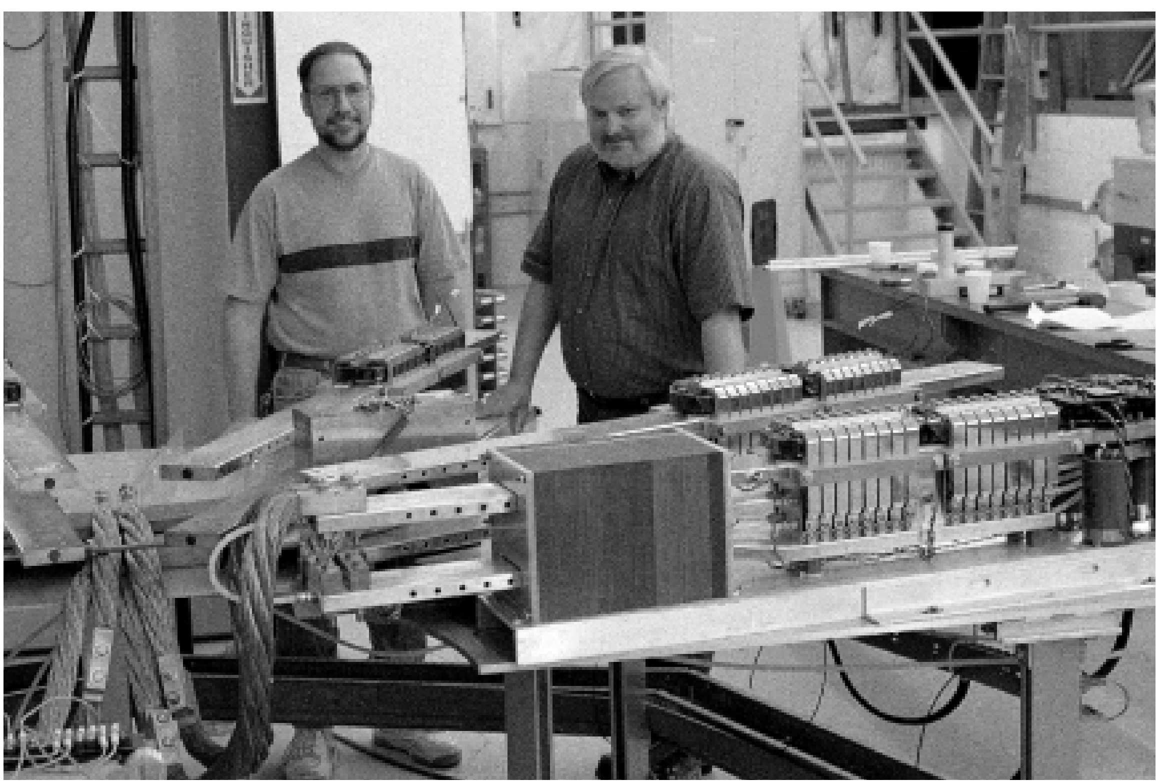

Photo by Jenny Mullins

Brad Claypool (left) and Steve Hays work on power supplies for future colliders, which will have power demands of ten or more megawatts.

On the Web:

Technical Division: www-td.fnal.gov

Beams Division: www-bd.fnal.gov

Linear collider: www-lc.fnal.gov

VLHC: www-ap.fnal.gov/VLHC/

Muon collider: www.fnal.gov/projects/muon_collider/

MASS PRODUCTION OF ACCELERATING STRUCTURES

Different kinds of accelerators present different challenges. Magnets are crucial to the design of proton accelerators. When it comes to accelerating electrons, the most important components are the accelerating structures.

Fermilab has joined the research efforts of two other high-energy laboratories, California's SLAC and Japan's KEK, which proposed the use of about 5,000 accelerating structures, each made of 206 copper disks, to build a new high-energy linear electron collider. The shape of the disks must adhere to very stringent design standards to allow the transmission of radiofrequency waves, the electromagnetic fields that accelerate the electrons.

"The current design requires the disk surface to be flat within one micron," said Tug Arkan, who engineers the production process. "The surface is so flat and shiny that nobody is allowed to touch it."

Assuring the quality of disks is one of Arkan's biggest concerns.

"Mechanical quality control systems rely on touching the disks, and that puts dents in them," he said. "Optical systems are much better, but they can only measure flat surfaces. We built a radiofrequency test stand that can check whether each disk has the correct 11.4 gigahertz resonance frequency."

Cutting the production cost is another concern. At Fermilab, Arkan and coworkers are setting up an R&D factory for the production of RF prototype structures.

"We try to industrialize the project," he explained. "At present, the RF structures are expensive to make, and they push technology to the extreme. We want to develop a production process that is capable of producing one million disks in three years with the least amount of scrap. [Because of the tight tolerances] we must use robotic systems. We cannot put human interaction into the game."

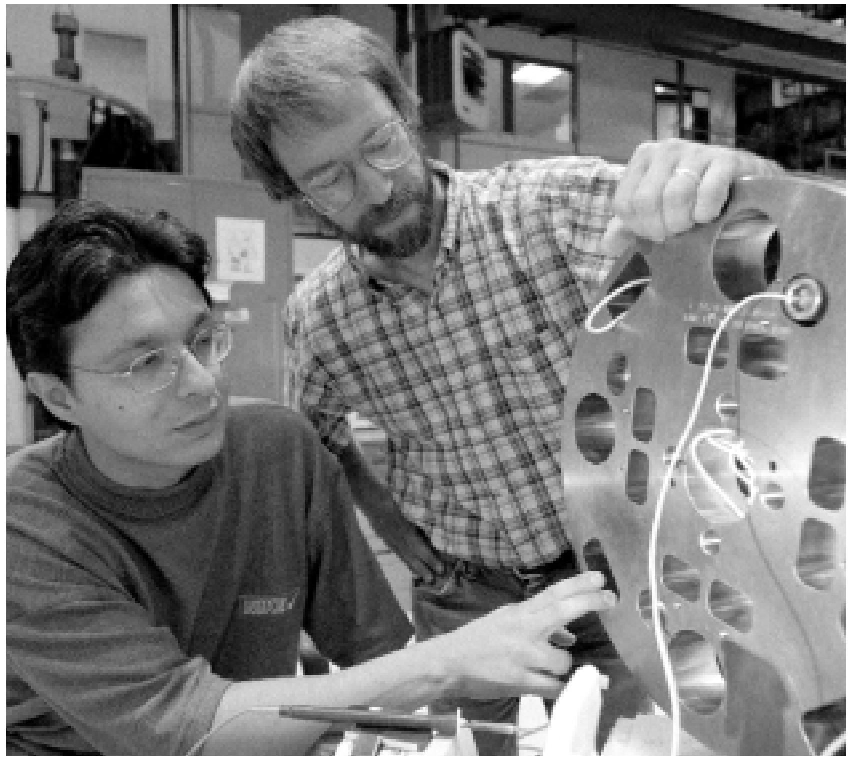

Photo by Reidar Hahn

Tug Arkan (here with Rodger Bossert, right) has worked on the LHC magnet design. Now he is lead process engineer for the high-precision production of intricate RF disks (below). Future linear colliders may have a million of these disks, 60 millimeters in diameter, to accelerate electron beams.

BUILDING COLLIDER FACILITIES

To operate magnets and accelerating structures, physicists need long tunnels. The LHC will be built in a tunnel about 27 kilometers in circumference.

For a linear collider with one million RF disks, scientists need a straight tunnel about 30 kilometers long. Working with the physicists of the project, engineers are investigating where and how such a tunnel could be built. The tunnel location is especially important.

"A linear collider is very sensitive to ground motion," explained Jeff Sims, a civil engineer who has worked on the layout of three different accelerators. "We try to understand very precisely how rock responds to cultural noise, like traffic on highways at the surface."

Finding the right solution is an iterative and innovative process, an aspect that Sims enjoys.

"There is a lot of brainstorming involved in projects at this level," said Sims. "The FESS engineering group acts as an in-house engineering consulting firm to the physicists. It is a fun group to work with."

Given the physicists' needs for new colliders, the fun will continue.

QuarkNet

VIDEO NEWS PROJECT
PART III

A Student's View: Live on the Internet

For the QuarkNet video news, high school students interviewed Fermilab scientists. Here Hilary Blanchard questions Amber Boehnlein about the DZero detector, with Jim Shultz of Fermilab's Visual Media Services capturing the interview on videotape.

Finally, all of our hard work has come together. During three intense days at Fermilab we immersed ourselves in an unusual mix: physicists, particles and broadcasting. Overcoming many obstacles and kinks, our four QuarkNet video groups aired our Fermilab experience live on Tuesday, April 24 in a webcast to classrooms around the country. We reached our goal, but we were nervous right up to the last second.

We are uniquely lucky students, living right next to Fermilab, and having the opportunity to talk to physicists, experience life at Fermilab and explore the promises and challenges of Run II. Since we are only a small fraction of the physics students of the world, we have set out to bring the rest here to Fermilab via the Internet. We've packed our Fermilab experience into four 15-minute newscasts for you to watch.

Our webcast conveys the excitement here at Fermilab from the view of a high school student. We present new physics ideas and concepts that could change our understanding of physics, science, our world, lives, and universe. We hope that anyone watching our videos will appreciate the research being done here at the lab.

Please tune in and enjoy your personal trip to Fermilab, touring its grounds, seeing its achievements and meeting its physicists.

See you then!

Hilary Blanchard

Photos by Reidar Hahn

Hilary Blanchard is a junior at West Chicago Community High School. She is one of 23 students who participated in the QuarkNet video news project.

The video news teams:

- *Illinois Math and Science Academy, and West Chicago Community High School*
- *Perspectives Charter School, and Proviso West High School*
- *Niles West High School*
- *Maine East High School, and Walter Payton College Preparatory High School*

Archived versions of the webcast are available at

http://quarknet.fnal.gov/run2/

CALENDAR

Website for Fermilab events: http://www.fnal.gov/faw/events.html

INTERNATIONAL FILM SOCIETY PRESENTS:

The Cup
May 11, 2001, 8:00 p.m., $4 ($1 for children under 12)
Dir: Khyentse Norbu, Bhutan (1999), 93 min. This charming film tells the story of a young Tibetan monk with a passion for soccer trying to install a satellite TV system in the monastery.

FERMILAB ART SERIES

Percussion Group Cincinnati
May 12, 2001, 8:00 p.m., $16
($8 for ages 18 and under)

"Music from Scratch",
May 12, 2001, 4:00 p.m.,
free percussion workshop

Back by popular demand, Percussion Group Cincinnati returns to Fermilab's Ramsey Auditorium. From the traditional sounds of drums, cymbals and to the more unusual sounds of amplified cactus needles, brake drums, and garbage cans, all are part of the PCG experience. These three outstanding musicians will present a free workshop/lecture/demonstration titled "Music From Scratch," geared towards any age or proficiency level.

For tickets or further information, please call our box office at 630/840.ARTS weekdays between 9 and 4.

NALWO
SPRING TEA
May 22, 10:00 a.m. to 12:00 noon.

Hosted by Beth Witherell at her home, site #29. Please bring a favorite dessert or appetizer from your traditional country, but if you cannot bring a treat please come anyway! For additional information contact Rose Moore, 630-208-9309 or cmoore@fnal.gov or housing office, 630-840-3777 or housing@fnal.gov.

SPRING PRAIRIE WALK
May 10, 2001, 10:30 am

NALWO invites all women to an on-site Spring Prairie Walk; please see http://www.fnal.gov/orgs/nalwo/prairiewalk.html or call Sue, x5059, for more information. Fermilab makes health a priority during National Employee Health & Fitness Day 2001

ONGOING
NALWO
Free English classes in the Users' Center for FNAL guests, visitors and their spouses. The schedule is: Monday and Friday, 9:30 a.m.-11:00 a.m. Separate classes for both beginners and advanced students.

DANCING

International folk dancing, Thursdays, 7:30-10 p.m., Village Barn, newcomers always welcome.

Scottish country dancing, Tuesdays, 7:30-10 p.m., Village Barn, newcomers always welcome. For information on either dancing group, call Mady, 630-584-0825 or Doug, x8194, or email folkdance@fnal.gov.

The Fermilab Barn Dance series, featuring traditional square and contra dances in the Fermilab Village barn, presents barn dances on Sundays. Admission is $5 for adults, $2 for age 12-18, and free for under 12 years old. Contact Dave Harding (x2971, harding@fnal.gov) or Lynn Garren (x2061, garren@fnal.gov) or check the WebPages at http://www.fnal.gov/orgs/folkclub/ .

WELLNESS WORKS
May 16, 11:30 a.m.-1:00 p.m.

Join Fermilab and Wellness Works in celebrating National Employee Health & Fitness Day 2001. Walk, run, rollerblade, your way around the ring. A table will be set up at A1 where participants may sign-in, pick up their game ticket, and a bottle of water. The largest percentage of participation from Divisions and Sections will win the traveling trophy, now held by Beams Division.

MILESTONES

AWARDED: PH.D.

- Michael James Fitch, University of Rochester (E886: Photoinjector)
- Bruce Knuteson, University of California at Berkeley (DZero)
- Sasha Kushnirenko, Carnegie Mellon University (E781: SELEX)
- Giuseppe Latino, University of Cassino & INFN Pisa (CDF)
- Amir Rahimi, University of Illinois (E831: FOCUS)
- Maria Spiropulu, Harvard University (CDF)
- David Wolinski, University of Michigan (CDF)
- Jeffrey Berryhill, University of Chicago (CDF)

REWARDED

With Fermilab Employee Performance Recognition Awards: Dave Augustine (ID 03375N, BD-AS-Mechanical Support Dept.), Phil Martin (ID 05111N, BD-DH-Headquarters Staff) and Bob Mau (ID 00843N, BD-BS-Accelerator Operations); by Fermilab Director Michael S. Witherell, on April 17, 2001; for their contributions to the successful launch of Run II.

RETIRING

- Carmen Rotolo, ID 2189, PPD-Engineering & Tech Teams, April 30, 2001.
- Kenneth Gray, ID 8028, PPD-Technical Centers, July 19, 2001; last day of work May 4.
- Lee Brown, ID 1104, BD-AS Mechanical Support, May 31, 2001.

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, MAY 9

Grilled Lemongrass Chicken Salad
Coconut Jasmine Rice
Pineapple Cake with Warm Ginger Salsa

DINNER
THURSDAY, MAY 10

Leek, Bean, Tomato and Roquefort Salad
Grilled Shrimp and Scallops in Champagne Butter
Sauteed Spinach and Pine Nuts
Lemon Risotto
Chocolate Fondue with Fruit

LUNCH
WEDNESDAY, MAY 16

Roasted Pork Loin
Vegetable of the Season
Apple Cake with Caramel Sauce

DINNER
THURSDAY, MAY 17

Seafood Salad
Soy-Marinated Pork Tenderloin with Shitake Cream
Gingered Sweet Potatoes
Pea Pods and Chestnuts
Plum Strudel

F N E E R W M S I

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http://www.fnal.gov/pub/ferminews/

The deadline for the Friday, May 25, 2001, issue is Tuesday, May 15, 2001. Please send classified ads and story ideas by mail to the Public Affairs Office, MS 206, Fermilab, P.O. Box 500, Batavia, IL 60510, or by e-mail to ferminews@fnal.gov. Letters from readers are welcome. Please include your name and daytime phone number.

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FERMINEWS MCMLXXVIII

CLASSIFIEDS

FOR SALE

■ '00 Tritan LSWC trailer. Top quality aluminum personal watercraft trailer. Less than 1,000 miles on trailer. Includes spare tire and bracket, extra large silicone bow roller, and wheeled tongue jack. Never in salt water, garage kept. $600 o.b.o. Call extension 8258 ask for Gayle or email Stephens@fnal.gov

■ '98 Wilderness travel trailer, 22′ Lite , excellent/like new, options loaded, sleeps six, $8,300. Call Tom x8510 or 630-978-3282, or sperry@fnal.gov.

■ '97 Chevy custom high top conversion van by Sterling, black, V8/350, 34k, excellent condition, 4 way power captain driver/passenger's seats, 2 removable capt. chairs and tri-fold power benchbed, gray leather, real wood interior, clothes rack, bug shield, rain reflector, privacy curtain window shades, mood/night lights, VCR/TV/2 radio systems, defrosting side mirrors, PS/B, A/C, new tires, security system. Asking $18,990 o.b.o. Diana x3704 or ladydi@fnal/gov.

■ '97 Dodge Neon Highline 4 door sedan, green, 4 cyl, PS, AT, AC, dual air bags, valet remote RF auto-start feature, Jensen CD/cassette stereo system, 3 year or 37,500 mile bumper to bumper limited warranty, Carfax clean title history guarantee, 56K miles, excellent condition, $4,550 o.b.o. Call Dave at 630-375-1477 home or 630-464-8078 cell phone.

■ '96 Mercury Grand Marquis GS beige, new Michelin tires, new shocks, remote locks, excellent condition, garage kept, 83K miles. $8,995.00 630-876-1959.

■ LE: Dodge 1500 4x4 Sport, Black w/grey int, 55,000 mi.(first 45,000 were country and highway miles), 360 cu. in., tow package, pwr windows and doors, spray-on bedliner, undercoated (inside doors etc.) and spray painted underneath (driveshaft etc)since new, brush guard, off road bars and 4 lights, side step bars, roll pan. All Mopar accessories. Bug shield, Sony 10 Disc, Cass. w/ removable face. After market alarm. Slightly oversized BF Goodrich all-terrains. Garaged and rarely driven in winter, one owner, mint condition. $15,000 o.b.o. Serious inquiries only. cdyrda@hotmail.com

■ '94 Grand Prix SE V6 2dr color blue with gray interior 82K miles excellent condition. $5,900 o.b.o. Contact Greg 630-272-5985.

■ '92 Mazda MX3 GS V6, 97k mi, good cond., well maintained, drives great, one owner. $3,000 o.b.o. Call x6736 or 630-692-1701, leer@fnal.gov.

■ '92 Camaro Rally Sport, 25th anniversary special. Teal, 48,900K, automatic, PS/PB power windows/locks, cruise control AM/FM cassette, new tires, Clifford alarm, $6,500 o.b.o. Scott 840-8437 or 761-3154 after 5:00 pm.

■ '90 Oldsmobile Ciera SL Cruiser wagon, 104K mi., very good condition, $3,490, Call Rich at x3880 or 630-690-1691.

■ '90 Plymouth Voyager SE minivan, maroon. 4 cyl. 2.5l engine, 91K miles, 7 pass., PDL, cruise, tilt, air, am/fm stereo cassette. Starts easily, runs well. Only 1 previous owner. Looks clean, some tiny door dings. $2,500. Page Henry P. 0141 or e-mail at: ehschram@fnal.gov or ehenry10@earthlink.net

■ '89 Buick LeSabre 4 dr. Runs great! Good dependable transportation. Asking $1,600, if interested contact Jack at x2812 or 815-741-4617 mateski@fnal.gov.

■ '89 Toyota Corolla 55,000 mi, New brakes and tires. Power steering and brakes, AM/FM, excellent mechanical condition, body has minor rust. Asking $2,500. Call Carol 840-2992

■ '85 Ford Crown Victoria wagon 87K, NS, garage kept, roof rack, low mileage tires, runs great one owner with all records. $1,500 o.b.o. X4415 or 630-377-3546.

■ '84 Ford Conversion Van, 70k, good motor, new tires $200, 630-553-9464.

■ '79 vintage Dodge Charger, special edition, 163K good condition, $2,000 o.b.o, 630-553-9464.

■ '77 Honda Goldwing 1000, excellent condition with Vetter fairing and packs, 66K miles. Lots of extras. Asking $1,100 o.b.o. Contact Gary at 896-6196 evenings.

FOR SALE

■ Sears Craftsman snow blower. 7hp, 24″ cut, 2-stage with electric start. Tire chains included. Machine is 25 years old but runs perfectly. $50.00. Contact Mark Shoun at ext #4157 or pager #0511.

■ Brand new, never used, Handspring Visor Deluxe (Infinitely expandable handheld computer with the soul of an organizer). From the creators of PalmPilot. This is an elaborate palm that allows you to incorporate accessories such as digital camera, modem, MP3 music player, universal remote, memory card/game pack. $190; Contact crogers@fnal.gov.

■ Sears Elgin 7.5hp outboard motor, $50, 27″ men's and women's bicycles, 10 speed, $20 each. Sievert@fnal.gov.

■ Sears fishing boat with 10 hp motor and trailer and life jackets $650. Scott 840-8437 or 761-3154 after 5:00 pm.

■ Queen Ann brass 3 toe antique table with leaf and 4 chairs $80, metal 3 drawer desk $10, student desk $30, motorized treadmill $75, stationary bike and stair stepper $10, 2 twin headboards $10, Queen brass headboard $5, hedger (used once) $55, old stereo turn table $10, very large wooden dog house $75. ladydi@fnal.gov.

■ Mac PowerPC Performa 6400/180, 72 MB RAM, 6.4 GB HD, tower/woofer, 15d monitor/speakers, ex modem, Epson 850 ink jet printer, HP scanner, 100 MB Zip, OS 9, WORD, EXCEL, Appleworks, Hypercard. No known problems, stable system. Never exposed to winter salt, used in Florida. ALL $700 x3769, Flora@fnal.gov

■ Rainbow SE vacuum cleaner with power nozzle and Aqua Mate, asking $500 o.b.o bennett@fnal.gov

■ Golf Clubs, Orlimar Trimetal Woods with graphite shafts, one year old, like new. 14+ 3wood and 18+ 5wood. $125 each. Jim x4293 or 585-0907.

■ All aluminum utility trailer; 6′ x 10′ low aluminum non slip platform with outside fenders; 2200# torsion axle; 13d wheels with a spare tire; full width aluminum ramp/tail gate; has stake pockets for attaching side boards; comes with an aluminum motorcycle ramp and 3 wheel chocks. The trailer is in excellent condition, is light weight, can be towed with a light vehicle, has about 5000 miles on it and is garage kept by the original owner. Asking $1,200. Call Rap @ 879-5506 or x3302.

HOUSE FOR SALE

■ 2-story house built in 1992, 4 bedrooms, 2.1 baths. Very popular Batavia neighborhood. Close to school, Fermilab and shopping. On a cul-de-sac with a large lot and water view. Loads of space. 2 car garage. The master suite boasts a deluxe bath with skylight. Two phone lines in every room and ISDN connection. Excellent value at $224,900. shekhar@att.net.

LOTS FOR SALE

■ 7.5 acres site is situated in a development in the Lee township and is located just about 2 miles west of Dekalb county and about 2 miles north of HWY 30. Site includes trees planted last fall and a field creek in the back section of the property. Asking $62,500. Call 815-627-9538 or email chappa@fnal.gov for property description and list of covenants.

■ Two acres-plus, agricultural lot, with building permit, on Immanuel Road, Yorkville, $80,000. 630-553-9464.

FOR RENT

■ 2-Bedroom apartment with new refrigerator, stove, air conditioner, and new tile floor. Includes carpeting in living room and bedrooms with drapes/shades on windows. Large bathroom, gas heating and water included. Tenant pays for own electricity. Laundry room facilities available. $795, 1 year lease. Phone 630-584-4686 or 630-573-4619; ask for Barb.

■ 4-bdrm home with 2 car garage. Excellent neighborhood in Aurora with private road. $1,100 per month plus one month security deposit. Utilities not included in rent. 630-801-1775.

■ House for short term rent (3 months) in Warrenville. May 1 to July 31, 2001. Only 1 mile from Fermilab. 3 bedrooms, 2 bath, living and family rooms, garage. Free access to Summerlakes club house and outdoor swimming pool. Price: $1,100/month or best offer. Please call: x8762 or 630-393-4862

LAWN CARE

■ Excellent lawn care for your home in West Aurora, North Aurora, and Batavia, call Roger 630-859-3789.

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