FERMI NEWS

FERMILAB A U.S. DEPARTMENT OF ENERGY LABORATORY

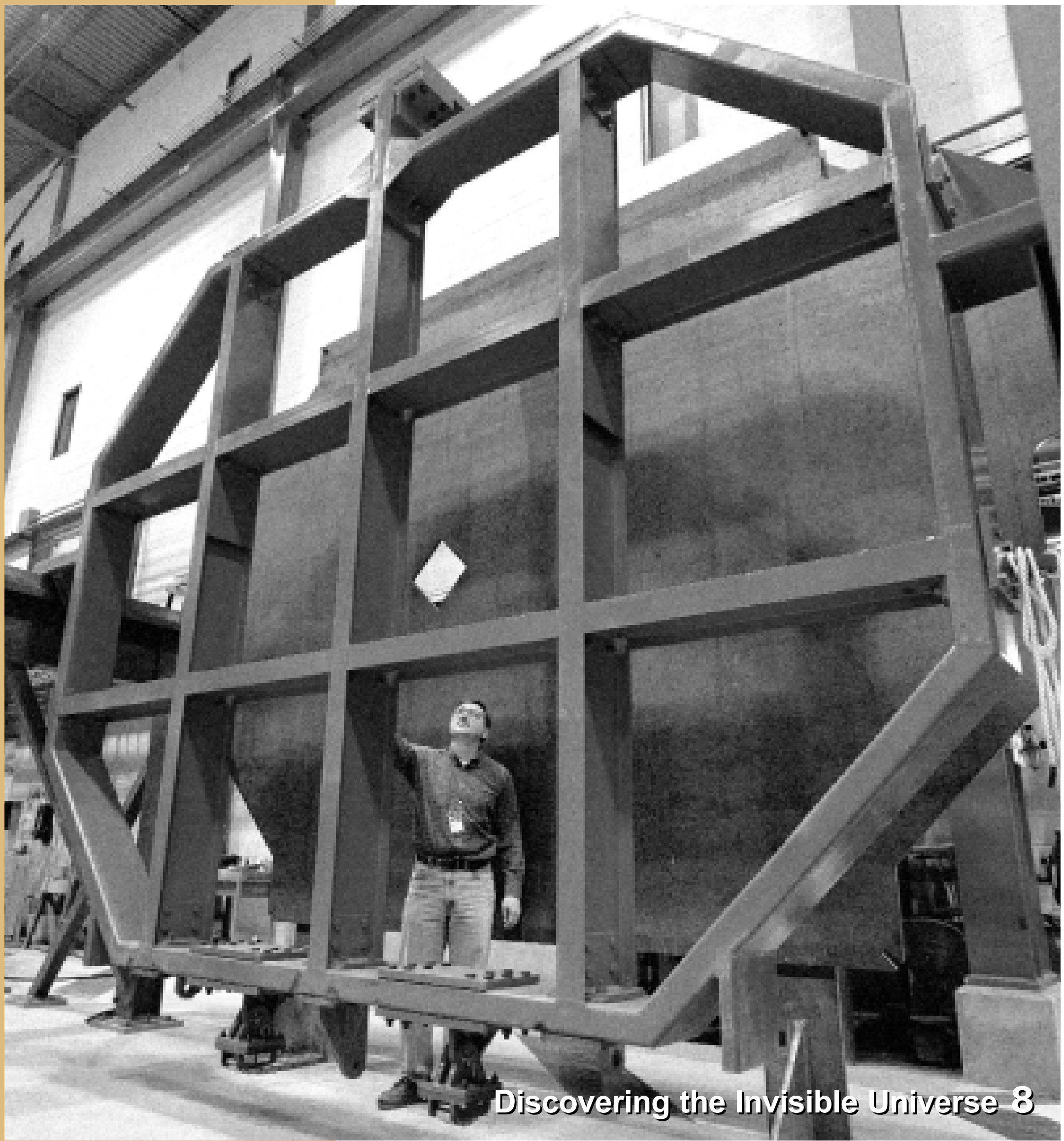


Photo by Reidar Hahn

Volume 25

Friday, March 29, 2002

Number 6

INSIDE:

"…the mind, that fiery particle…"
—Lord Byron

THE INQUIRING MIND OF A HIGH SCHOOL STUDENT OFFERS A SERIES OF CHALLENGING QUESTIONS FOR A FERMILAB PHYSICIST

On the Web

Inquiring Minds:
http://www.fnal.gov/pub/inquiring/index.html

"Dear Monica…"

Questions about physics pop up continually through the Fermilab website, but some exhibit a level of engaging curiosity that sets them apart and begins an extended dialogue of questions and answers. Monica Charpentier, a junior at Dulaney High School in Timonium, Maryland submitted a question about the property of charge. "Just what is it?" she wanted to know. Her query found its way to Fermilab theorist Andreas Kronfeld, who welcomed the opportunity to follow her questions and insights to succeeding levels of complexity.

The dialogue begins with Monica's original question in her first email…

Monica: What exactly is this force that causes electrons to be attracted to protons, but repelled by each other?

Andreas: In the most basic theory of the force between charged objects, physicists view it as an exchange of photons. Photons are little particle-like ripples in the electromagnetic field. The idea is that an electron comes with an electric field (and, if it is moving, also a magnetic field). But this field is felt by other charged particles: we picture a photon leaving the electron and, a bit later, bumping into or being absorbed by another charge. If this other charge is the same as that of the electron, it gets pushed away. If it has the opposite charge, it gets pulled in. I'm not sure that you will be happy with this explanation, because all I have done so far is replace an incomprehensible force with an incomprehensible "electromagnetic field" and its photons.

Monica: What exactly is the state of being "negative" or "positive"? Why are there only these states (and neutral)?

Andreas: The terms "negative" and "positive" have developed partly from convention, and partly from observation. Benjamin Franklin is generally credited with originating the idea of positive and negative charges.

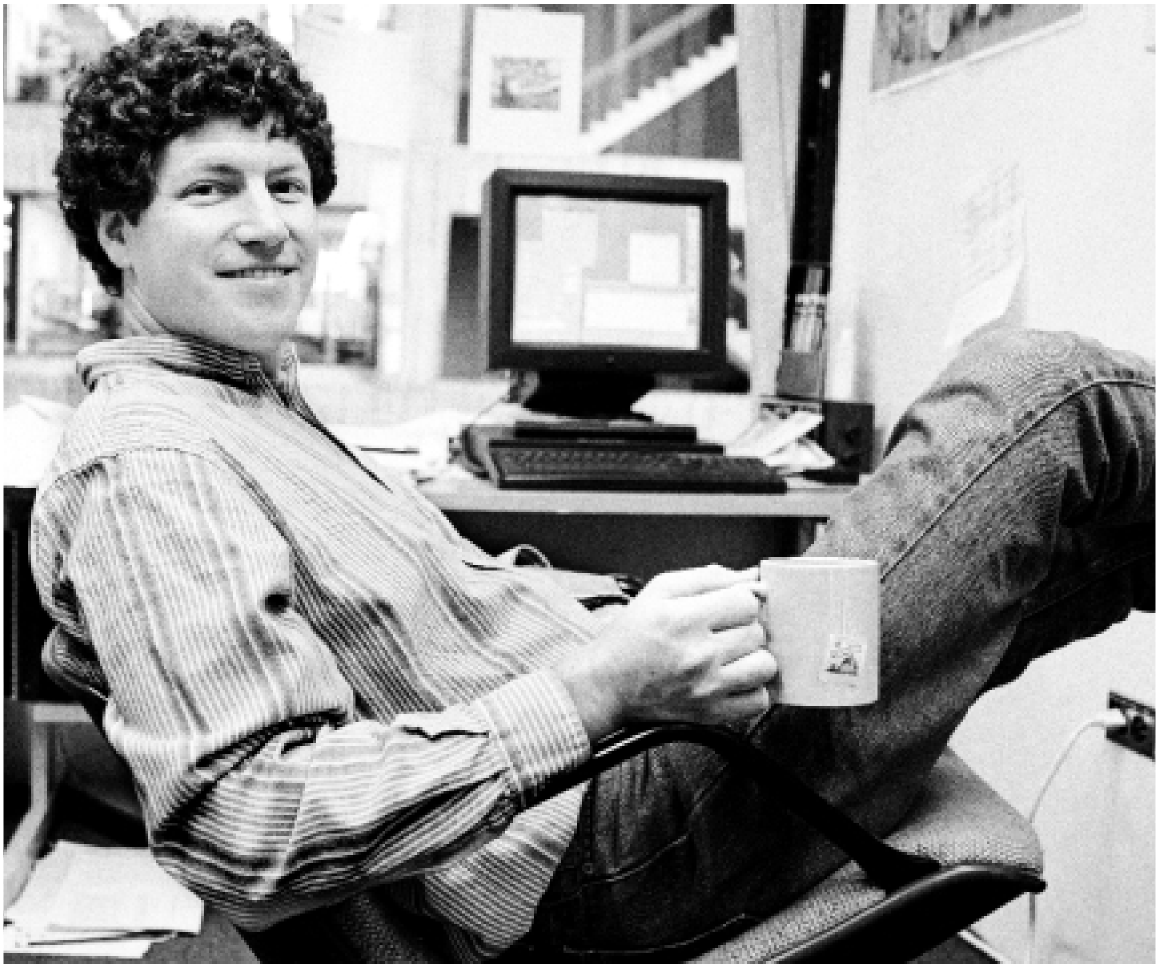


Photo by Reidar Hahn

Fermilab theorist Andreas Kronfeld was happy to take on the challenge of a dialogue with an inquiring high school student.

In experiments (including Franklin and his famous kite-flying), we have observed that various objects repel or attract each other. When these objects are combined, their total repulsion or attraction can be related mathematically. By combining the right amount of repulsive and attractive stuff, the total can end up having essentially no repulsion or attraction.

To summarize all these observations, we simply say that matter has a property that we call electric charge. An object with no repulsion or attraction corresponds to having no charge (or is said to be electrically neutral). Then, mathematically, it makes sense to assign negative values of the charge to some objects, and positive to others. That way, they can add up to zero. By historical convention, we assign negative charge to the electron. Since a proton is attracted to the electron, and since the bound state of electron and proton (a hydrogen atom) is neutral, we conclude that the proton has positive charge.

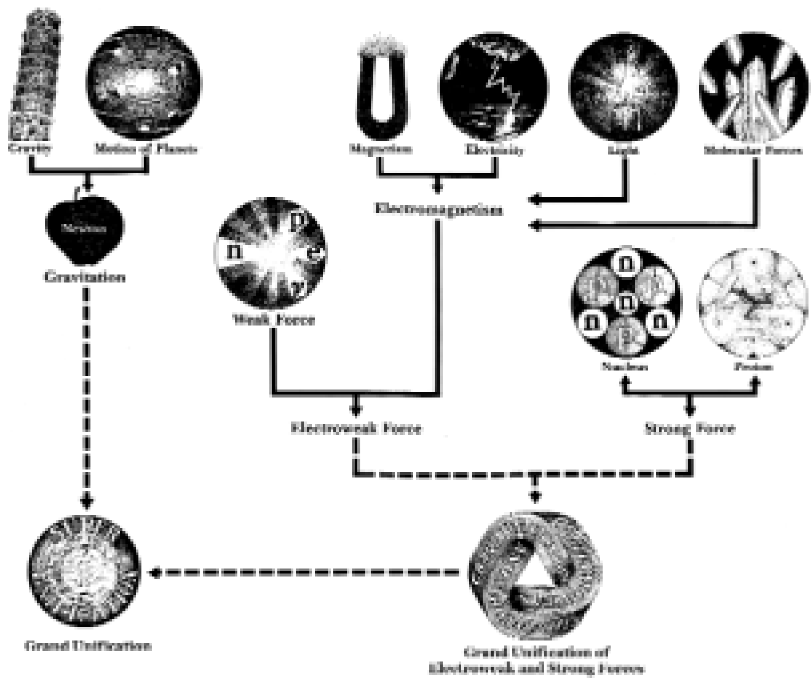
Well, once again, I am not sure that you will be happy with this explanation, because I've reduced to it to words that summarize a long series of observations of nature. The answer probably does not yet get at the question: "What exactly…"

Maybe a contrast will help. There is another force, called the strong force. In our most basic theory of the strong force, called chromodynamics, there is a property (again, summarizing lots of observations) that is in some ways like charge. But instead of having two aspects (positive and negative), it has three aspects. If you combine the same amount of all three aspects, the total behaves in an essentially neutral way. We particle physicists call this corresponding property "color." It's a playful analogy with ordinary colors: if you combine the same amount of blue, red, and green light, you get white light. Everything bigger than a proton is colorless, but some particles called quarks, inside protons, do have color.

Monica: To put it concisely, what exactly *IS* a charge? How does such a thing exist, and why does it cause objects to interact the way they do?

Andreas: Unfortunately, it is hard to answer "what exactly" questions. Science does not work in that way. Rather than striking at the core, we peel off layers. In the case of charge, we start by watching

"Dear Andreas..."



Unification of the Forces

As this chart shows, the forces of magnetism and electricity have been unified as the electromagnetic force. They were further unified with the weak force as the electroweak force. Gravity and the strong force have resisted unification so far. Illustration by Angela Gonzales

objects move. We notice that the motion is more complicated than would be explained by gravity and by manual pushing. So we say there is an electric force. Then, in deducing the force law (Coulomb's law), it is convenient to introduce electric charge: it is easier to remember the electron's charge, and Coulomb's law, than to memorize the whole pattern of motion.

We move on from electric forces to electric and magnetic fields, again because the fields, which are more abstract, allow us to forget more details of real observations. For example, it is a lot easier to predict the properties of electrical circuits and electric motors by using the field concepts. Finally, it is a lot easier to understand the details of the electron's behavior with the concept of the photon.

If you think about peeling off one layer at a time, the amazing thing about physics is this: from each inner layer, we can reconstruct all the layers farther out, without having to repeat everything that enabled us to understand the outer layers at the start. But we can understand nature very well—in the sense of making precise predictions about what will happen—without knowing all about the layers farther in.

Let me give an example: Some books and articles say that Einstein "proved Newton wrong" by finding a better law of gravity. Actually, Einstein found the next layer of understanding. Newton's law of gravity is still good enough for NASA to use it in guiding spaceships through our solar system and beyond, and even have them land on the moon (which required very fine control). Similarly, many theoretical physicists are trying to figure out the next layer farther in from Einstein's.

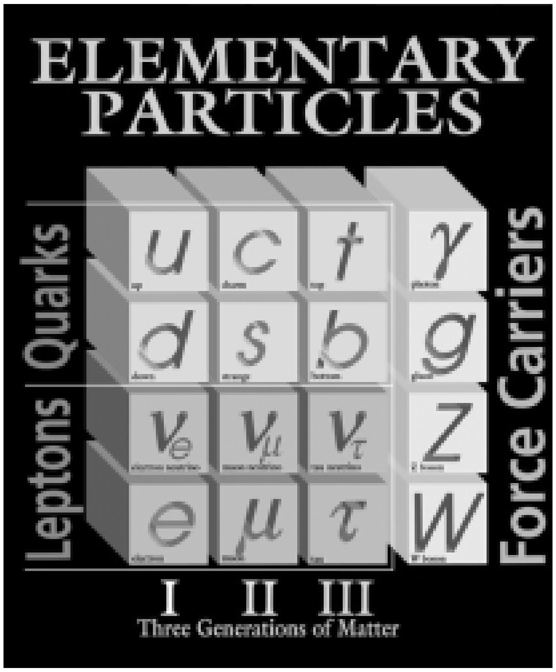
At Fermilab, and a few other leading research labs, we are trying to get from the so-far innermost layer of understanding to the next ones farther in. Asking, "what's next?" is less philosophical than "what exactly…" but it turns out to be exciting and challenging enough, and also more successful.

Monica: I am afraid that I have yet another question. The websites that I visited said that the strong force holds the nucleus together. I understand how the strong force binds the quarks together. What I didn't see in these explanations was an explanation of whether the strong force also affects quarks in the other protons or neutrons within the nucleus.

Andreas: It is the same strong force. The strong force binding protons and neutrons together into a nucleus is a residue of the even stronger force among the quarks. The same phenomenon occurs with molecules, but in that case, it stems from electromagnetic forces. In chemistry, you may have heard of "van der Waal's forces." These forces are the residue of electromagnetic forces binding electrons to the nuclei within the molecules.

Monica: Do quarks that are already confined in hadrons exchange gluons with quarks in different hadrons? [Hadrons are particles made of strongly-interacting constituents (quarks and/or gluons). Gluons are the carrier particles of the strong interaction—*Ed.*]

Andreas: Yes, they do. But the gluon exchanges of quarks within a single hadron tend to cancel each other out. So if a neutron and a proton are almost on top of each other, the force is still quite strong; but if they are far apart, the force between them almost vanishes. Again, van der Waals forces act in the same way; they, too, are quite short range in their effect.



Fermilab graphic

The Standard Model has governed particle physics since the 1970s.

Additionally, the quarks themselves have different electrical charges, and are confined (despite these opposite charges) because the strong force is much more powerful than the electromagnetic force. This being the case, do quarks in different subatomic particles feel attraction to each other? Basically, they do: the strong force among quarks is about 40 or 50 times stronger than the electromagnetic force among them. If the charges are the same (like the two up quarks in a proton) the electromagnetic force trying to push them apart is overwhelmed by the strong force holding them together.

Monica: So could a positive quark in a proton be attracted to a negative quark in a different proton?

Andreas: Yes. In this case both the strong and electromagnetic forces are attractive. But, you also have to add up all the forces from all the quarks. Thus, consider two protons. If they are far apart, all the strong forces basically cancel out, and you are left with the repulsive electromagnetic force of two charges. If they are close together, the net strong force is still pretty strong. Not quite strong enough to bind them, but if you put one neutron and two protons close together, they will bind into the helium-3 nucleus.

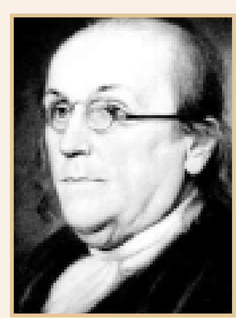
Monica: Thanks for reading and answering these emails! If I were to work in a field such as particle physics, I would definitely want to be part of the discoveries. I sometimes worry about the math, but if I decide that particle physics is for me, I will have had the equivalent of three years of calculus before entering college. I think I will be a lot more comfortable with math in general by then.

Andreas: I find it encouraging that you would prefer to be part of the action. The way to become strong in math is through practice. The same principle applies to athletics, where you don't learn the high jump from reading books about it. Talent helps, instruction helps, and books help. But practice makes perfect.

Ben Franklin: The Plus and Minus

From *"The First American: The Life and Times of Benjamin Franklin,"* by H.W. Brands, here is a description of Franklin's ongoing correspondence begun in 1747 with Peter Collinson in London. Collinson was an agent of the Library Society of Philadelphia, and a scholar with scientific interests similar to Franklin's:

"In one of his first letters, Franklin supplied a novel terminology that became standard in analyzing electrical phenomena. Describing a particular apparatus, consisting of bodies labeled *A* and *B*, he wrote: 'We say *B* (and other bodies alike circumscribed) are electrised *positively*; *A negatively*. Or rather *B* is electrised *plus* and *A minus*.' …At a time when other electricians spoke of two different kinds of electricity—vitreous and resinous—Franklin unified the field by positing a single sort and explaining the opposite properties in terms of a surfeit or a deficit (that is, positive condition or negative) of this single electricity, with uncharged objects being in balance."



Ben Franklin, who besides studying electric charge, also invented bifocals.

INTERACTIONS

Communicating particle physics in the 21st century

Join the dialogue on physics communication. This week's questions for discussion:

1. How would you express the highest-level goals of particle physics at the start of the 21st century?

2. In your best hopes and dreams, what advances will particle physics achieve in the next 30 years?

Respond online at www.fnal.gov/pub/ferminews/interactions/index.html or send email to ferminews@fnal.gov

by Judy Jackson

It's a moment familiar to anyone from a particle physics laboratory. The person next to you on the plane or at the party turns to you and says, "So what do you do?"

"Particle physics."

"Oh?"

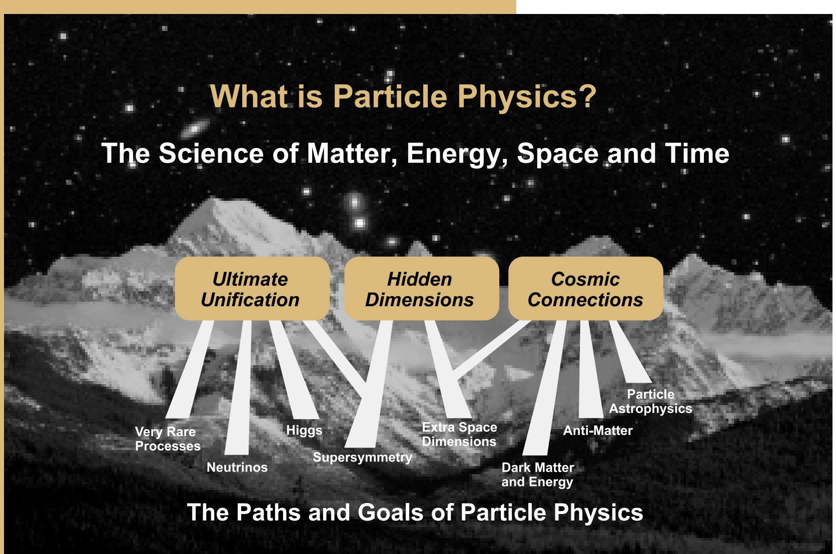
Then what?

What to say, in the few moments conventionally allotted for such a response, to convey to the hapless person beside you the sheer joy and excitement of working in a field of science that is at this very moment on the verge of discoveries that promise to revolutionize the way human beings understand the fundamental nature of the universe, using international research tools of an unprecedented scale and complexity that push the frontiers of advancing technology, whose discoveries will have profound—but profoundly unpredictable—consequences for society at some unspecified time in the future, in an unseen realm that is at the same time almost unimaginably small and as large as the universe itself, which, by the way, may have many more dimensions than heretofore dreamed of?

"I work on the precise determination of the width of the W boson." will not cut it. Neither will "I am attempting to unify quantum mechanics and the theory of general relativity."

A sound bite we're not.

The science of particle physics has embarked on an extraordinary voyage of discovery that truly does promise to revolutionize the way we understand the universe. In the metaphor of Stanford Linear Accelerator Center's Communication Director Neil Calder, we can see the coconuts and the tree trunks floating on the waves, we can smell the spices—we've almost reached the unknown shore.

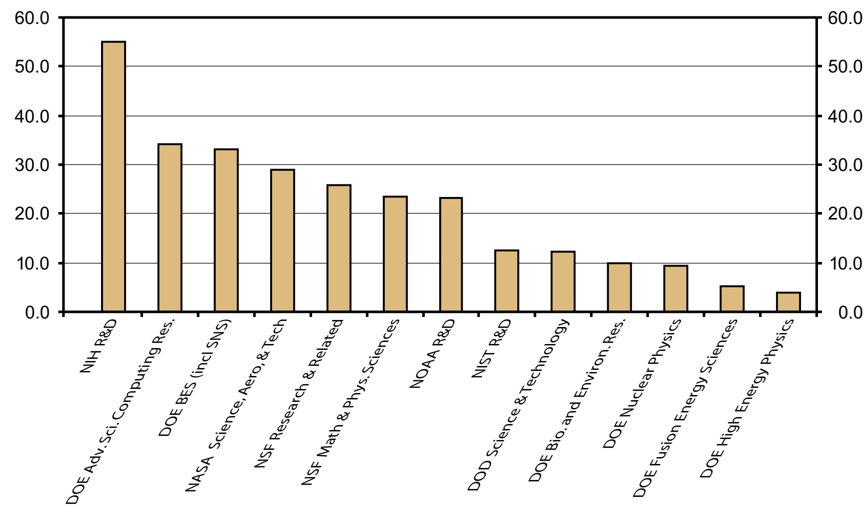


Work in progress: This diagram, adapted from the recently released Long-Range Plan for the Future of U.S. High-Energy Physics, attempts to illustrate the true sweep and significance of the field of particle physics. How effective is the diagram? Ideas for improvement? Share your views online at, www.fnal.gov/pub/ferminews/interactions/index.html.

And yet, at this moment in the voyage the wind appears to be slackening.

Physicist John Marburger, former director of Brookhaven National Laboratory and now director of the U.S. Office of Science and Technology Policy, had this to say in an address on U.S. science policy to the American Academy for the Advancement of Science last month.

% CHANGE IN FUNDING, FY 2000 (ACTUAL)—2003 (REQUEST)



The bottom line:

Federal support for high-energy physics continues to drop.

"Today," Marburger said, "the frontiers of the large and the small—of astronomy and particle physics—remain unconquered. But they have receded so far from the world of human action that the details of their phenomena are no longer very relevant to practical affairs. Not by accident, the instrumentation required to explore them has become expensive. Because we can no longer expect that society will benefit materially from the phenomena we discover in these remote hinterlands, the justification for funding these fields rests entirely on the usefulness of the technology needed for the quest, and on the joy we experience in simply knowing how nature works. (A joy, I am afraid, that is shared fully by a rapidly declining fraction of the population.)"

"Remote hinterlands?"

Remember, these words come from a *friend* of particle physics. Somehow, the excitement and the promise of particle physics are not getting through where it counts.

Part of the problem, physicists and policy makers agree, is that we in high-energy physics have trouble articulating the goals of our science in terms that are compelling to those beyond our field. Pinning another chloroformed particle to the Standard Model board does not get us where we want to go. The prospect of capturing one more boson, however fat and juicy, does not generate the level of interest that biomedicine and genetics, for example, have inspired in recent years.

The ability to communicate the essence of 21st century particle physics might not matter so much were it not for the ineluctable fact of the "f" word—funding. For better or worse, particle physicists have chosen a field of research that requires very expensive tools. If accelerators and detectors were not so extraordinarily costly, particle physicists might retire to commune with the quarks and the bosons and with one another. Perhaps they might prefer it that way. But as a practical fact, particle physicists have no choice but to interact with the rest of the world, because they depend on the rest of the world to provide the tools of their trade.

The results of that interaction between physics and society have not, at least not recently, translated into a high level of support for the field.

Realizing the promise of the 21st century voyage of discovery will require a new kind of strategic communication for particle physics.

"Communication as usual" is unlikely to generate the kind of change that is needed. Forthcoming issues of *FERMINEWS* will examine the issues and opportunities facing particle physics communication at a moment that many regard as decisive for the course of this field of science not only in the United States but throughout the world.

As the series unfolds, *FERMINEWS* readers are invited to join the dialogue, either by email to ferminews@fnal.gov or at a special Physics Communication web page at www.fnal.gov/pub/ferminews/interactions/index.html.

EXPLORING the invisible UNIVERSE

by Kurt Riesselmann

COVER PHOTO: Chris White of Illinois Institute of Technology, leads a team that assembles planes, like the one shown here, for the MINOS near detector. Each of the detector's 282 planes consist of scintillator modules inside aluminum boxes, and 12-foot-tall steel plates.

On the Web:

Neutrino physics at Fermilab
www.fnal.gov/pub/inquiring/physics/neutrino/

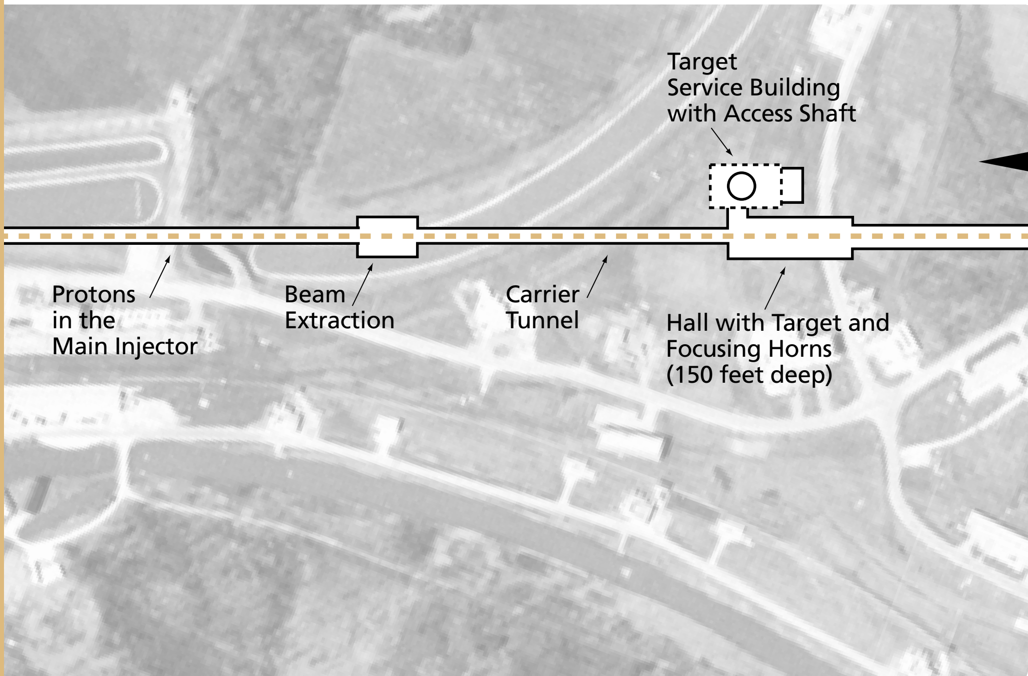
The NuMI-MINOS project:
www-numi.fnal.gov

Neutrino projects around the world
wwwlapp.in2p3.fr/neutrinos/anexp.html

The sun. The moon. The stars. For thousands of years people have tried to understand the things they see in the sky. Little did they know that there is much more than meets the eye.

During the last decade, astronomers and physicists have discovered that about ninety-five percent of our universe is invisible even to the best telescopes. Developing indirect observation techniques, scientists have "seen" black holes, dark matter, three types of ghost-like particles called neutrinos and a mysterious, dark force that speeds up the expansion of the universe. We still know very little about all this "stuff," except that it is invisible to the naked eye.

Scientists at Fermilab are deeply involved in unraveling the secrets of this invisible universe. An experiment called the Cryogenic Dark Matter Search looks for new types of particles that could be building blocks of dark matter. The Sloan Digital Sky Survey has begun to record a detailed three-dimensional map of the sky, providing vast amounts of data on clusters of galaxies that seem to harbor black holes and dark matter. And the MiniBooNE and MINOS collaborations will take a close look at the properties of hard-to-detect neutrinos, which may account for as much



mass as all the stars combined: a few percent of all mass and energy in the entire universe.

In the past few years the Super-Kamiokande experiment has overturned the long-standing dogma that neutrinos are massless. Studying neutrinos created in the earth's atmosphere, the experiment has found evidence for neutrino oscillations, a phenomenon that can only occur if neutrinos have mass. Although the mass of a single neutrino is believed to be tiny, much less than the mass of an electron, the abundance of neutrinos in our universe could make them an important factor in the formation of galaxies and the evolution of the universe.

The Main Injector Neutrino Oscillation Search will build on the success of Super-Kamiokande. Instead of working with atmospheric neutrinos, however, scientists will create an intense neutrino beam using protons from the powerful Main Injector accelerator at Fermilab. To study the neutrinos, MINOS scientists are building two large detectors, which they will place at two different points along the neutrino beam.

CREATING GHOST PARTICLES

Scientists classify neutrinos as weakly interacting, an optimistic view given the fact that a neutrino can easily traverse the breadth of our planet without leaving a trace. To increase the chance of witnessing a collision of a neutrino with an atomic nucleus, scientists prefer to use intense, man-made neutrino beams. Fermilab initiated the Neutrinos at the Main Injector (NuMI) project, beginning the construction of underground beam lines and halls in May 2000. When NuMI is complete, scientists will send a package of 20,000 billion protons every two seconds to a hall 150 feet underground, where the protons will smash into a target and create neutrinos.

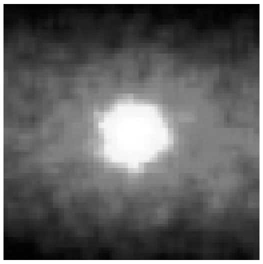
"The proton beam is only several millimeters wide at the target location," explained Bruce Baller, who manages the beam line design and installation. "The proton beam will travel through a series of little graphite plates, a total length of about one meter. Scientists at the Institute for High Energy Physics in Russia are building this target."

The target converts the protons into bursts of particles with exotic names such as kaons and pions. Like a beam of light emerging from a flashlight, the particles form a wide cone when leaving the target. A set of two special lenses, called horns, is the key instrument to focus the beam and send the particles in the right direction.

Drawing an electric current of 200,000 amps, about twenty thousand times more than a hairdryer, the horns produce powerful electromagnetic fields that keep the pions and kaons from spreading too far.

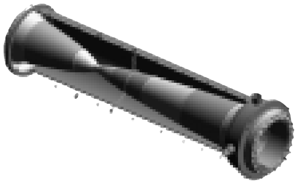
To save energy, scientists operate the horns in pulsed mode, creating a focusing field two milliseconds long every time a proton package hits the target. The interiors of the horns have the shape of parabolic cones made of 2.5-millimeter-thick aluminum.

Switching the electromagnetic fields on and off creates stresses and vibrations inside each horn, a bit like the forces occurring inside a musician's horn. To ensure top performance, the different horn sections are welded together with tolerances only slightly larger than the thickness of a hair. In the last year, engineers have successfully tested a prototype horn for about five million pulses.

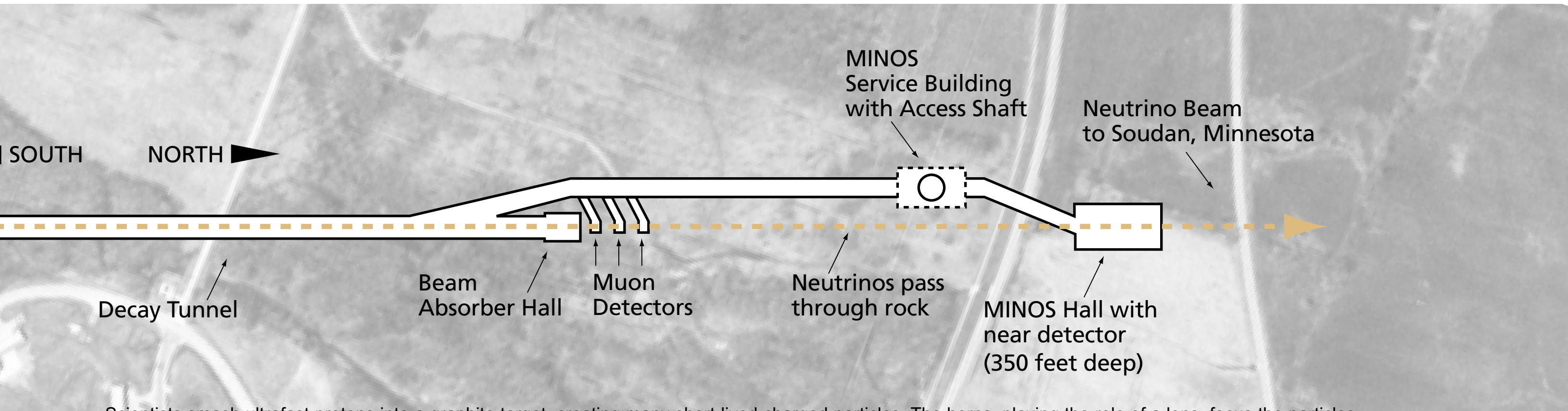


R.Svoboda, Louisiana State U.

The image of the sun created by neutrinos, as seen by the Superkamiokande experiment.



The horns focus the beam and direct it on its way.



Scientists smash ultrafast protons into a graphite target, creating many short-lived charged particles. The horns, playing the role of a lens, focus the particles into the forward direction, where they decay into neutrinos, muons and other light particles. After about 1,500 feet, a beam absorber stops all particles except muons and neutrinos. In the alcoves located behind the beam absorber, physicists measure the muon paths to verify the direction of the neutrinos, which travel approximately in the same direction. The rock located between the alcoves and the near detector will stop all muons, leading to a pure neutrino beam. The near detector verifies that the beam consists only of muon neutrinos. After traveling 450 miles through rock, the beam then traverses the far detector, which records how many muon neutrinos have disappeared.

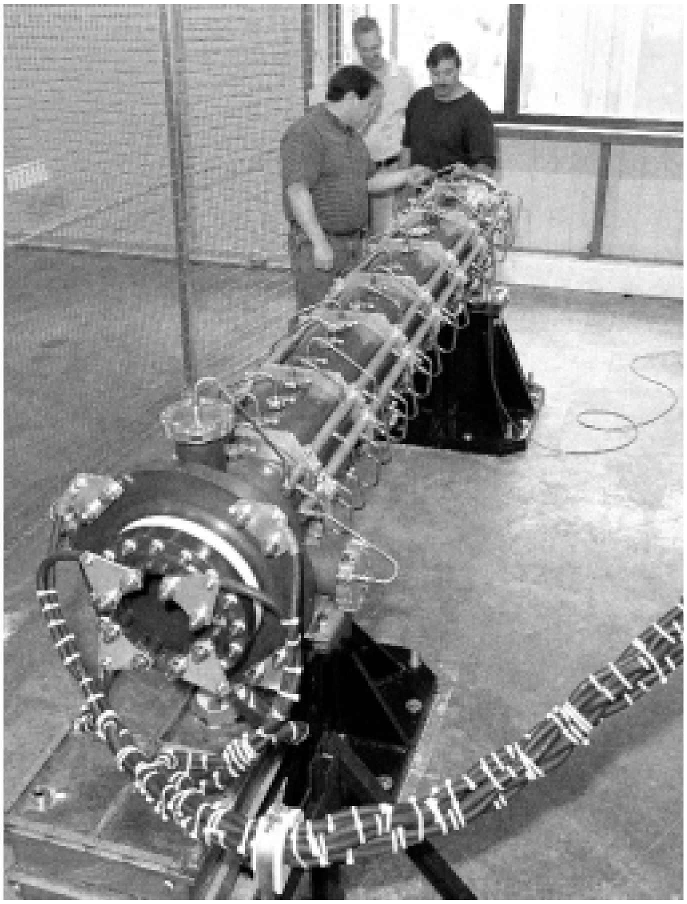


Photo by Reidar Hahn

This device, called a horn, is essential to focusing a neutrino beam. Kris Anderson (right) pushed technology to its limits to produce high-precision welds between the different sections of the parabolic interior of the horn.

"Kris Anderson has been working on the design of the horns for several years," said project engineer Dave Pushka, who coordinates the work of more than a dozen mechanical engineers on the NuMI and MINOS projects. "It's a wonderful, very thoroughly analyzed device. We are pushing the envelope in terms of technology. Kris has developed the welding procedure for the horns. It is extremely high quality, like that used for the space shuttle and fighter jets."

Studying a Magic Trick

After leaving the horns, the pions and kaons decay into muon neutrinos, one of three types of neutrinos known to physicists. Muon neutrinos, however, seem to be capable of a special trick: traveling at almost the speed of light they can slowly disappear. Scientists have reason to believe that no magical forces are at play however. Instead, they suspect that the muon neutrinos change their identity, transforming into either electron neutrinos or tau neutrinos, and reappearing at a later time. According to the laws of quantum physics, this behavior, called neutrino oscillation, is quite acceptable—assuming that neutrinos have mass.

"I think that essentially everybody is convinced that there is a disappearance effect in the Super-Kamiokande data," said physicist Stan Wojcicki, professor at Stanford University and spokesperson for the MINOS experiment. "The neutrino oscillation hypothesis gives a perfect fit to the data. But there are also other models that explain the data."

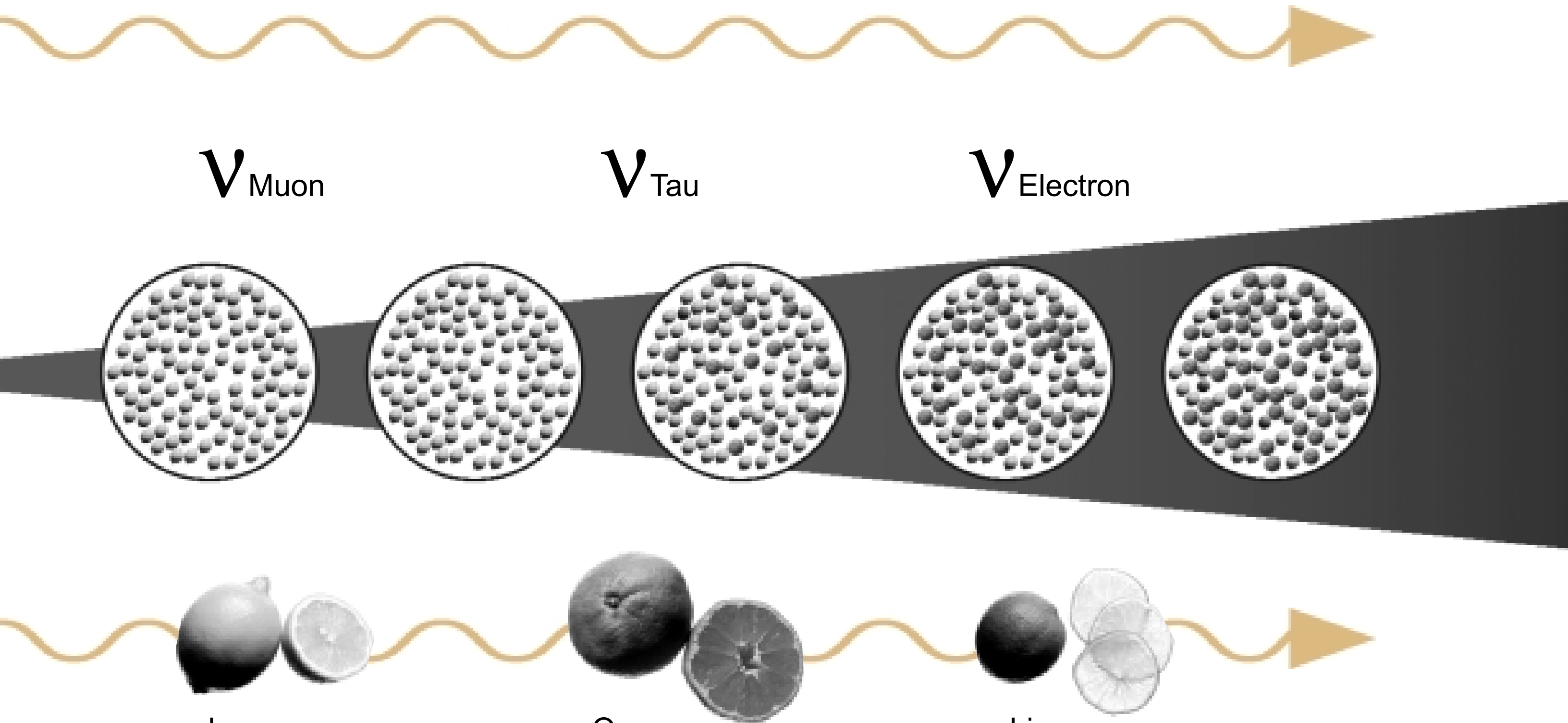
Some theorists have suggested that muon neutrinos may instead decay into new particles not identified so far. Other physicists wonder whether muon neutrinos could oscillate into sterile neutrinos, a fourth type of neutrino that interacts with matter even less than the three types already known.

The MINOS collaboration is determined to uncover the truth using the Fermilab muon neutrino beam. To check the oscillation hypothesis, physicists will measure the number of muon neutrinos at two points along a 450-mile long path that takes the neutrinos from Batavia, Illinois to an iron mine in Soudan, Minnesota. When construction is complete in 2004, the collaboration can verify the Super-Kamiokande disappearance result in a few months. It will take about two years to carry out the more important part of the experiment, investigating whether the disappearance is due to oscillations.

Sandwiches of Steel

The unique setup of the MINOS experiment allows scientists to determine the shape of the oscillation wave. Tuning the energy of the man-made neutrino beam, a feat not possible with atmospheric neutrinos, scientists will measure the strength of the oscillation curve at various points, locating the maxima and minima of the curve by comparing the neutrino events observed in the two detectors.

To succeed with their experiment, MINOS scientists need to catch enough neutrinos at both the Fermilab site and at Soudan. The MINOS collaboration is building a 1,000-ton neutrino detector at Fermilab, which will sample the muon neutrino beam about 3,400 feet from the target, where the oscillation curve is still very close to its maximum. This near detector consists of 282



On its 450-mile long trip through the earth from Batavia, Illinois to Soudan, Minnesota, the content of the neutrino beam is expected to change. Starting from a pure beam of muon neutrinos (represented by lemons), scientists expect a fraction of the beam to transform into tau neutrinos (oranges) and—less likely—electron neutrinos (limes).

planes, each containing a one-inch steel plate and a layer of scintillating material, which collects the light caused by a neutrino collision inside the steel.

“The scintillator modules are being made right now at Argonne National Lab,” said Fermilab physicist Catherine James, who leads the team constructing the near detector. “At Fermilab, we have begun to put the first modules on one-inch-thick steel plates, twenty-one feet wide, twelve feet tall.”

James expects that the near detector will observe tens of neutrino events every two seconds, corresponding to the proposed design rate of protons hitting the target. Up in Soudan, where the larger far detector is under construction, it will be more difficult to test the beam. Despite the use of top-quality focusing horns, the cone of the neutrino beam will increase significantly in diameter along the 735-kilometer trip through the earth.

“By the time it gets up there, the neutrino beam will be four kilometers wide,” James said. “The detector in Soudan is only eight meters wide. We will be lucky to get one thousand neutrino events per year.”

Fortunately, simulations have shown that such a sample will suffice to map out the whole oscillation curve as a function of energy.

“The Super-K results determined what beam energy we should start with,” James said. “Based on the most recent results and the distance between our two detectors, we’ve optimized the initial neutrino beam energy.”

The construction of the far detector is progressing faster than expected, and technicians will have installed the first of two 2,700-ton supermodules by the end of June. The components for the near detector will be ready in December. Scientists, however, won’t have access to the new MINOS detector hall until next year due to delays in the excavation schedule (*FERMINEWS,* vol.24, no.16, Sept. 28, 2001). Nevertheless, James is excited about the prospects for the MINOS experiment.

“Even with the unfortunate delays that occurred,” she said, “the results will be a great and timely contribution to the field.”

Best Friends

Friends of Fermilab mark 20 years of support for education programs

by Mike Perricone

The early days: Leon Lederman (left) confers with Friends of Fermilab Jim Ruebush, physics teacher at St. Charles High School; Stanka Jovanovic (standing); Marge Bardeen (seated); Batavia banker Robert Riley, and Judy Schramm, in 1985.

Fermilab photo

Like many pivotal ideas, the Friends of Fermilab, who have supported and enriched the lab's educational programs for two decades, owe their origins to hard work, dedication, timing and good food.

More than 20 years ago, then-Fermilab director Leon Lederman, good-naturedly described by a colleague as "a frustrated professor," had noticed teachers arriving along with students for his Saturday Morning Physics lectures. He had an idea, and he took that idea to the most effective forum he could imagine: the Wilson Hall cafeteria.

"In early 1981, Leon started talking around the lunch tables, saying that Fermilab should do something to help science education in local schools," said Stanka Jovanovic, wife of Fermilab physicist Drasko Jovanovic, and herself a research chemist at Argonne National Laboratory. "He needed private funds. I heard about it through Drasko, and wrote Leon an outline on how to go about raising funds for such a purpose."

A few years previously, Stanka Jovanovic had put together a not-for-profit organization to support music education in Downers Grove School District 58. A referendum had cut funding for the music program, a cut Jovanovic found unacceptable.

"My daughter was in that program," she recalled, "and I refused to let her be without music."

A few months later, Drasko and Stanka Jovanovic dined with Ellen and Leon Lederman, and the topic arose again.

"Leon asked if I could help Fermilab create a foundation, and I realized he was quite serious," Stanka said. "I decided to call Marge Bardeen, who at that time was president of the Glenbard School Board, thinking that if she were willing to get involved, I would do it."

Bardeen (now head of Fermilab's Education Office) agreed. They invited Jean Fisk, also an educator (and wife of physicist Gene Fisk), and the late Bob McCullough, a local businessman knowledgeable in fund raising, to join the effort. Lederman asked Judy Schramm, then his executive assistant, to help. To establish a theme, they assembled a group of teachers, scientists

On the Web

Fermilab Education Office
http://www-ed.fnal.gov/ed_home.html

Friends of Fermilab Program History
http://www-ed.fnal.gov/ffla/pep_main.html

Friends of Fermilab Board of Directors
http://www-ed.fnal.gov/ffla/ed_ffla_dir.html

A Nation at Risk
http://www.ed.gov/pubs/NatAtRisk

Photo by Reidar Hahn

QuarkNet students get a vision of virtual reality at Fermilab. QuarkNet is one of many programs that have benefited from the Friends of Fermilab over the years.

and professors, had a meal, and asked: "What would the goals of a high-school program be for you?"

Within a month, there was a proposal to create Friends of Fermilab, a not-for-profit foundation to raise funds for precollege science education programs at the lab. The Fermilab Board of Trustees approved the proposal in October, 1982. Bardeen asked Marge Cox (wife of physicist Brad Cox), then Director of Instruction for the Glenbard School District, to help organize a science education needs assessment, identifying what Fermilab could do to help local schools.

"We wanted to know how to match up their goals with Fermilab's resources," Bardeen said. "We met on a Saturday over lunch. We had quiche."

The result was a proposal for "The Summer Institute for Science Teachers at Fermilab."

Concern for education was in the air. The National Commission on Excellence in Education, formed in 1981, was about to release its findings. The commission included Nobel Prize winner Glenn T. Seaborg, physicist Gerald Holton of Harvard, and president A. Bartlett Giamatti of Yale. They described their report as "An Open Letter to the American People," and titled it, "A Nation at Risk: The Imperative for Educational Reform."

"On March 11, 1983, our proposal was mailed to 50 local foundations," Jovanovic recalled. "A few days later the 'Nation at Risk' report was announced, and on March 16 we had all the money we needed to run the 1983 Summer Institute. Friends of Fermilab was incorporated earlier the same month. The rest is history."

And quite a story, as well.

From 1983 to 1989, before the establishment of the Fermilab Education Office, the Friends of Fermilab raised $1.7 million toward educational programs. In their nearly 20 years of operation, the Friends have raised a total of $4.5 million. The benefits? Last year, as an example, Fermilab's education programs reached approximately 24,000 elementary-to-high-school-age students, and 6,400 teachers.

The second Symposium on the Nature of Science, held March 16 in Wilson Hall, is an example on a grand scale of the Friends' support. But examine the range of Fermilab's education programs, and the imprint of the Friends is unmistakable. In QuarkNet, the Friends add to a program funded by DOE. LinC, in its 10th year of training master teachers who train other teachers to integrate the Web into their classroom and curriculum, receives significant outside support in addition to such funding sources as the State of Illinois.

Over the years, the Friends' support has been critical in operating programs such as Problem Solving in Mathematics; Physics Mini-Courses; Hands-On Science; Teaching Integrated Math and Science (TIMS, which grew into a math textbook series); Particles and Prairies; Quarks to Quasars—the list goes on and on. And the Leon M. Lederman Science Education Center, celebrating its 10th year, could not have been built without the support of the Friends.

"The Science Education Center has had a profound impact on science education in the community," said George S. Zahrobsky, retired chairman of the Science Department at Glenbard West High School in Glen Ellyn, who has been a board member since the beginning. "For me it has been a great honor to serve with Marge and Stanka from the onset of Friends of Fermilab."

There's just one catch in the anniversary celebrations: the Friends feel that their name doesn't convey an adequate description of their commitment to education, and the function of the group in raising funds for students and teachers in the community, not for the operation of the lab.

"We'd like to change the name," Bardeen said, "and we're thinking of holding a contest. We'd certainly welcome suggestions."

Based on history, discussing it over lunch might not be a bad idea.

Photo by Reidar Hahn

At the March 16 Symposium on the Nature of Science, Thomas Greytak told the adventure story of the Bose-Einstein condensation, a quest spanning seventy years in time and eight orders of magnitude in temperature—and a quest that led to the 2001 Nobel Prize in Physics for Eric A. Cornell, Wolfgang Ketterle, Carl E. Wieman. Greytak, himself a prominent Bose-Einstein researcher, is a professor of physics at MIT and the Associate Department Head for Education.

CALENDAR - THURSDAY, APRIL 25

DASTOW 2002

Fermilab employees, here's your official annual invitation to DASTOW2002 (Daughters and Sons To Work) and Earth Day at Fermilab. Once again, DASTOW will offer its annual array of activities for lab employees and their children.

There will be a group photo in front of Wilson Hall (make that newly-refurbished Wilson Hall!), followed by a gathering in Ramsey Auditorium for our kickoff presentations and last-minute information on the day's schedule. Then the fun really gets underway: Tom Peterson's "field guide" to the butterflies of Fermilab; Jerry Zimmerman's Cryo Show; a special presentation by the Fermilab Fire Department; the "Go For It!" panel discussion with women scientists and engineers; a look at the buffalo barn, and DASTOW posters at the end of the day. Plus: for "early birds," Peter Kasper will again conduct his early-morning birdwatching expedition. You'll need to sign up for the tour, and space is limited.

Watch the Fermilab website (http://www.fnal.gov) for more details as the day draws near. Or call the Office of Public Affairs at 630-840-3351.

EARTH DAY

Plant prairie seeds, plant a tree, have a hot dog—it's the annual Earth Day celebration at Fermilab. Bring a shovel and wear gloves and boots. The activities will take place at the corner of B Road and Wilson Road (the same area as last year), starting at 11:30 a.m. and continuing until all the seeds and trees are planted. Fermilab taxi service will be provided, with pickups at the ground floor, west side entrance.

TREE PLANTING INSTRUCTIONS:

- Make sure your hole is dug properly—not too deep or too shallow. There will be a diagram to show you the correct way to dig.
- Do not remove wire baskets or burlap. They will decompose under the soil.
- Completely untie twine from tree trunk.
- Pack soil tightly around tree ball.
- Create a soil ring around tree to retain water.
- Firmly grab hot dog and direct toward mouth.

Photo by Reidar Hahn

For more information, call Fermilab Roads and Grounds (630-840-3303) or contact Mike Becker: becker@fnal.gov.

CALENDAR

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

MEET SCIENTISTS AT SCIENCE EDUCATION CENTER

The popular Ask-a-Scientist program takes place every Saturday from 1 to 3 p.m. at Fermilab's Lederman Science Education Center. Scientists will meet visitors to answer questions ranging from "What is dark matter?" to "How do you accelerate a particle close to the speed of light?" The Science Center with its hands-on science displays is open Monday through Friday from 9 a.m. to 4 p.m. and every Saturday from 9 a.m. to 3 p.m. Visitors must use the Pine Street entrance.

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.

FERMILAB ARTS AND LECTURE SERIES:

CAROL WINCENC, FLUTE & NANCY ALLEN, HARP

Saturday, May 4, 2002 $17 ($9 ages 18 and under)

Carol Wincenc Masterclass, sponsored by the Chicago Flute Club at 4 p.m.

"An impeccable flute soloist." — The New York Times

Critically acclaimed recitalists Carol Wincenc & Nancy Allen team up to present an elegant evening of music for flute and harp. These gifted artists have traveled throughout the United States and abroad, garnering rave reviews and standing ovations wherever they perform.

Their program will include works by Gorecki, Bach, Tower, Gossec, Ravel, Ibert, and Bartok. Opening night festivities will include a masterclass by Ms. Wincenc, sponsored by the Chicago Flute Club, a pre-concert talk and formal reception.

LUMA

Saturday, April 20, 2002
$18 ($9 ages 18 and under)

"The show never fails to amaze, it is literally and figuratively illuminating."
— Chicago Tribune

LUMA embodies a breakthrough in family performance art, similar to those of Imago, Mummenschanz and Michael Moschen. Using new light technologies and various performance art disciplines, LUMA transforms a darkened theater into a spatial canvas, where three-dimensional illuminated objects and chaotic characters paint surreal worlds of colorful motion. Fireflies dance, fireworks explode, and iridescent maidens trapeze to an eclectic score in a performance that is part puppetry, part dance, part fireworks, with a little Big Top action thrown in. The Philadelphia City Paper described LUMA as "a magical treat in the dark. It's part visual lullaby and part sweet, funny circus of light.

THE DARK SIDE OF THE UNIVERSE:

Beyond Stars and the Starstuff We Are Made Of

Dr. Michael Turner, Fermilab and University of Chicago
Friday, April 5 at 8 p.m., Ramsey Auditorium
Tickets: $5

Cosmologist Michael S. Turner is trying to crack the mystery of why the expansion of the universe is speeding up and not slowing down, and the nature of the dark energy causing that expansion.

All Fermilab Arts and Lecture Series programs begin promptly at 8 p.m. in Ramsey Auditorium, in Wilson Hall. For more information, call 630-840-ARTS, send a fax to 630-840-5501, or email audweb@fnal.gov.

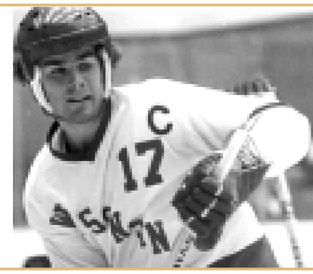
Fermilab is only accessible from the west side entrance at Pine Street and Kirk Road. For a map or further information, please see our web page at www.fnal.gov/culture.

CORRECTION

WISCONSIN 17, FERMINEWS 0

The list of U.S. Users by State of Home Institution ("Users: Fermilab Wouldn't be the Same Without Them," *FERMINEWS*, vol. 25, no. 5, Mar. 15, 2002) inadvertently omitted the state of Wisconsin and its 17 users. *FERMINEWS* regrets the error.

In recompense, here's a picture of Mike Eaves, recently named hockey coach at the University of Wisconsin-Madison, wearing his No. 17 jersey when he was a two-time All-America for the Badgers in 1976-78. All of the state's 17 users are from Wisconsin-Madison.



Chez Léon MENU

Lunch served from 11:30 a.m. to 1 p.m.
$10/person

Dinner served at 7 p.m.
$23/person

For reservations, call x4512
Cakes for Special Occasions
Dietary Restrictions
Contact Tita, x3524
http://www.fnal.gov/faw/events/menus.html

Lunch
Wednesday, April 3

Lasagna Rolls Stuffed with Ricotta, Spinach and Prosciutto with a Sundried Tomato Sauce
Green Bean and Roasted Red Onion Salad
Amaretto Flan

Dinner
Thursday, April 4

Mustard Blini with Smoked Salmon
Cider Marinated Duck Breast with Spicy Mango Chutney
Barley and Mushrooms
Strawberry Tart

Lunch
Wednesday, April 10

Closed

Dinner
Thursday, April 11

Booked

FERMI NEWS

FERMILAB
A U.S. DEPARTMENT OF ENERGY LABORATORY

Ferminews is published by Fermilab's Office of Public Affairs.
Phone: 630-840-3351

Design and Illustration:
Performance Graphics

Photography:
Fermilab's Visual Media Services

Ferminews Archive at:
http://www.fnal.gov/pub/ferminews/

The deadline for the Friday, April 12, 2002, issue is Tuesday, April 2, 2002. 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.

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

CLASSIFIEDS

FOR SALE

■ '01 Honda 400ex ATV, exc shape 440 big bore kit, jet kit, k&n filter, fmf bars, dg skid plate, black shockwears on it since new, yellow and blk plastic, runs great $4,500 o.b.o. x4871 or pgr. 630-905-02125, or 815-754-2018 mcarten@fnal.gov.

■ '94 Dodge Ram 1/2-ton 4x4, std cab long bed, 102K miles, good shape runs exc, slt model fully loaded, 5 spd tranny, two sets of wheels, blk w/grey interior, 5.2 v8, soft tonneau cover, 3-inch body lift, air cond. $9,500 o.b.o. call x4871 or pgr. 630-905-02125, or 815-754-2018 mcarten@fnal.gov.

■ '93 Nissan Sentra XE, silver-grey, 2 door, 5 spd. 120K, 6 CD changer/cassette, cruise control, power steering, power mirror, sunroof. Runs great $2,250 o.b.o. Lucas x4366 or nxuan@fnal.gov.

■ '91 Toyota Celica 2 door GT coupe. 5-speed manual transmission, A/C, AM/FM compact disc player, 106K miles, red, rear spoiler, extra clean condition. $2,750, call 630-833-7208.

■ '93 Harley Davidson Softail, needs work, $10,000 o.b.o. Steve 1-815-895-8852 or e-mail Pam at pkisham@fnal.gov.

■ '95 Ski-Doo mxz 440 liquid cooled snowmobile, good shape runs good, comes with spare hood and belt and plugs, 1.5 inch track in decent shape seat has one small tear not noticeable, has top of the line hpg rebuildable shocks, 3,900 miles, not even 50 miles on fresh rebuild, had new cylinders and head and pistons, rings, etc... $1,800 o.b.o. x4971, pager 630-905-0215, or 815 754-2018 email mcarter@fnal.gov

■ '76 Cutlass rim, centercap and mounted tire. $10. Call X6342 or 708-645-1168 (evenings).

■ Weight bench, bar, leg lift, dumb bells, collars $20 for all lawn trailer $30. Chest of drawers, night stand, dresser with mirror all for $150. Greg x3011 or 630-557-2523.

■ Zano's Spa and Salon Gift Card for sale. $70 value, great gift idea. Call Jerry at X4571.

■ Furniture refinishing and restoration. Pick-up and delivery services available. Call 815-695-5460 or x3762.

■ Full size refrigerator/freezer for free if you come get it. Almond color. Works fine. Approx 15 years old. 630-483-0636.

■ Wanted: Electric treadmill in working condition. Reasonably priced. Please call Linda x2062 or blomberg@fnal.gov

HOME FOR SALE

■ Beautiful 3 bedroom tri-level in Lake Holiday, 2 bath, professionally landscaped, Sandwich Schools, large lot, 3 beaches, boating, fishing, water-skiing, low taxes. Available after April 1, 2002. $145,900. Call ext. 3499.

FOR RENT

■ 1-bedroom apartment in secured building, just 3 miles from Fermilab, completely furnished. Close to 88 tollway and train station. Central air, cable TV, telephone, whirlpool, heat,and electricity included. Contact by e-mail: irina@fnal.gov by phone x50-74 or 815-756-6099 after 7pm.

LABRADOR AVAILABLE

■ Sparky is a friendly 8-yr-old chocolate Labrador. He is an inside dog, but enjoys spending time outdoors. He is neutered and is current on his vaccinations. Due to allergies he can no longer stay with us. If interested, call Diana at 630-844-1259, or email diana@appraisalservices.com.

NOON BIBLE CLASS

■ Each Wednesday at noon in the Huddle off the Cross Gallery. You are invited. Jeff Ruffin x4432, ruffin@fnal.gov.

GOLF LEAGUE

■ The Fermilab Golf League is looking for golfers to participate in our weekly golf league that plays nine holes at the Fox Valley Golf Club in North Aurora on Tuesday afternoons from April to August. Please visit our web site, http://mccrory.fnal.gov/golf, for details and an application form, or call Elliott McCrory at x4808. Please reply with confirmation of receipt.

BARN DANCES

■ Sunday, April 14 at 6:30 p.m. with music by the Common Taters and calling by Paul Ford. Sunday, April 21 from 2 to 5 p.m. with music by Stephie & the Boyz and calling by Lynn Garren. Fermilab barn dances, held in the Warrenville Community Building, feature traditional square and contra dances. Admission is $5 for adults, $2 for age 12-18, and free for under 12 years old. Come with a partner or without; bring the family or not. For more information contact Dave Harding (x2971, harding@fnal.gov) or Lynn Garren (x2061, garren@fnal.gov) or check the webpage at http://www.fnal.gov/orgs/folkclub/ .

MILESTONES

AWARDED

■ The 2001 Bruno Pontecorvo Prize: to B.N. Samios, Brookhaven National Laboratory, in recognition of his outstanding contribution to particle physics; at the 91st session of the Scientific Council of the Joint Institute for Nuclear Research, held in Dubna, Russia on 17-18 January 2002.

RETIRING

■ Robert Trendler, ID 1584, PPD-Electrical Engineering, effective April 30, last day March 29

■ Michael Van Densen, ID 1957, BD-AS-Electronic Support, effective June 20, last day April 19

DIED

■ On March 13, Prem Srivastava, 68, Fermilab guest scientist from Istitito de Fisica, Universidade do Estado de Rio de Janeiro, Brazil. Srivastava worked on many aspects of quantum field theory. His most recent work was on light cone quantization of the Standard Model.

ADVANCED STUDY INSTITUTE on Techniques and Concepts of High Energy Physics

June 13-24, 2002 in St. Croix, US Virgin Islands

The 12th biennial Advanced Study Institute on Techniques and Concepts of High Energy Physics will be held June 13-24, 2002 in St. Croix, US Virgin Islands. The school is sponsored by the NATO Science Program, the High Energy Physics Program of the DOE, the Elementary Particle Physics Program of the NSF, the Fermi National Accelerator Laboratory, Florida State University and the Institute for Experimental and Theoretical Physics (Moscow). This highly successful, and popular, school is intended for advanced graduate students, or recent PhD recipients, from a NATO, Partner or Mediterranean Dialogue Country. For detailed information please visit the school's web-site http://www.physics.fsu.edu/ASI.

Note: The organizers are flexible about the deadline; therefore you should still apply if you're interested.

F E R M I L A B
A U.S. DEPARTMENT OF ENERGY LABORATORY

Office of Public Affairs
P.O. Box 500, Batavia, IL 60510

First-Class Mail
U.S. Postage
PAID
Bartlett, IL
Permit No. 125