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The Fermilab Stheory Group

In Theory

For every fundamental particle, the theory of supersymmetry proposes a supersymmetric partner, a “sparticle” in SUSY jargon. The electron, e, for example, has a SUSY spartner, the selectron ẽ. Would every Fermilab theorist have a SUSY “stheorist”? Probably not, but theorists worldwide will be watching Tevatron Run II for the first experimental evidence for SUSY.

The Fermilab Theory Group

INSIDE

2 Supersymmetry

7 Supersymmetry Workshop

8 MiniBooNE

10 Fishing

12 Paperless Papers

14 CDF Party

SUPERSYMMETRY

…and the physics of Run II

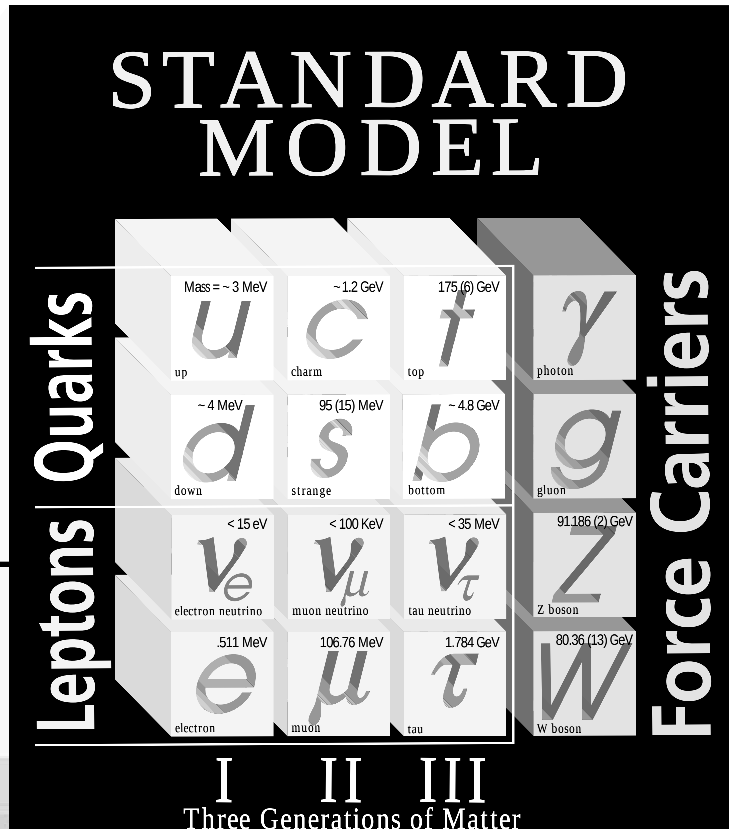
by Meher Antia

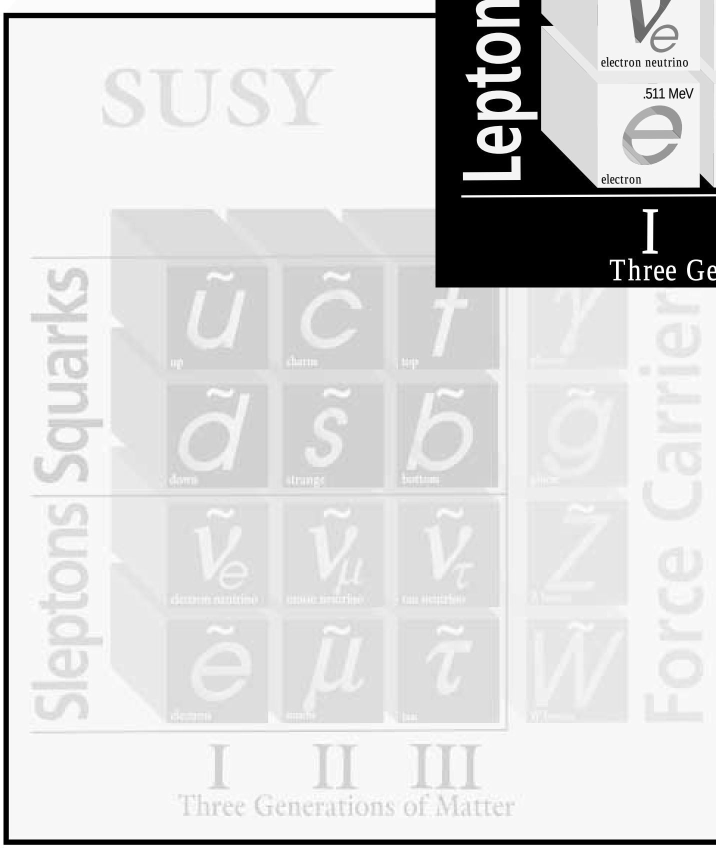
Without resorting to tricky mathematics or exotic physics, anyone can see that much of the stuff the world is made of has mass. Things can be touched and felt; they have some bulk, unlike, say, light which is intangible and immaterial. But why? Why are some things in the universe, like quarks and leptons, chunky and massive and others, like photons and gluons, ethereal and massless?

CRITICAL PATH

Answers to questions like these are usually provided by the Standard Model, to date the best framework to describe the patchwork of elementary particles and forces of nature. However, in its simplest form, the Standard Model disappoints. It clearly states that all particles should be massless, just like the photon. How, you might ask, can the Standard Model retain its reputation as the best description of nature if it makes a prediction that so blatantly flies in the face of even the least perceptive observer?

The Standard Model retains its position because there is a fix to the mass problem. A particle called the Higgs boson, yet to be observed, is conjured as part of a mechanism to bestow mass upon particles in a way that is consistent with experimental results. Still, the fix of the





In its simplest form, the Standard Model fails to account for different particle masses. To solve this problem, theorists have invoked supersymmetry, a theory that provides a supersymmetric particle partner, or "spartner" for each of the known fundamental particles.

Photo by Jenny Mullins

Supersymmetry could manifest itself in many different ways. Theorists, including Fermilab's Joe Lykken, left, are still on the fence about exactly what form it might take. "That's why we need our experimental colleagues," says Lykken, shown here with theorist Xerxes Tata, of the University of Hawaii, attending CDF's 20th birthday party on May 20.

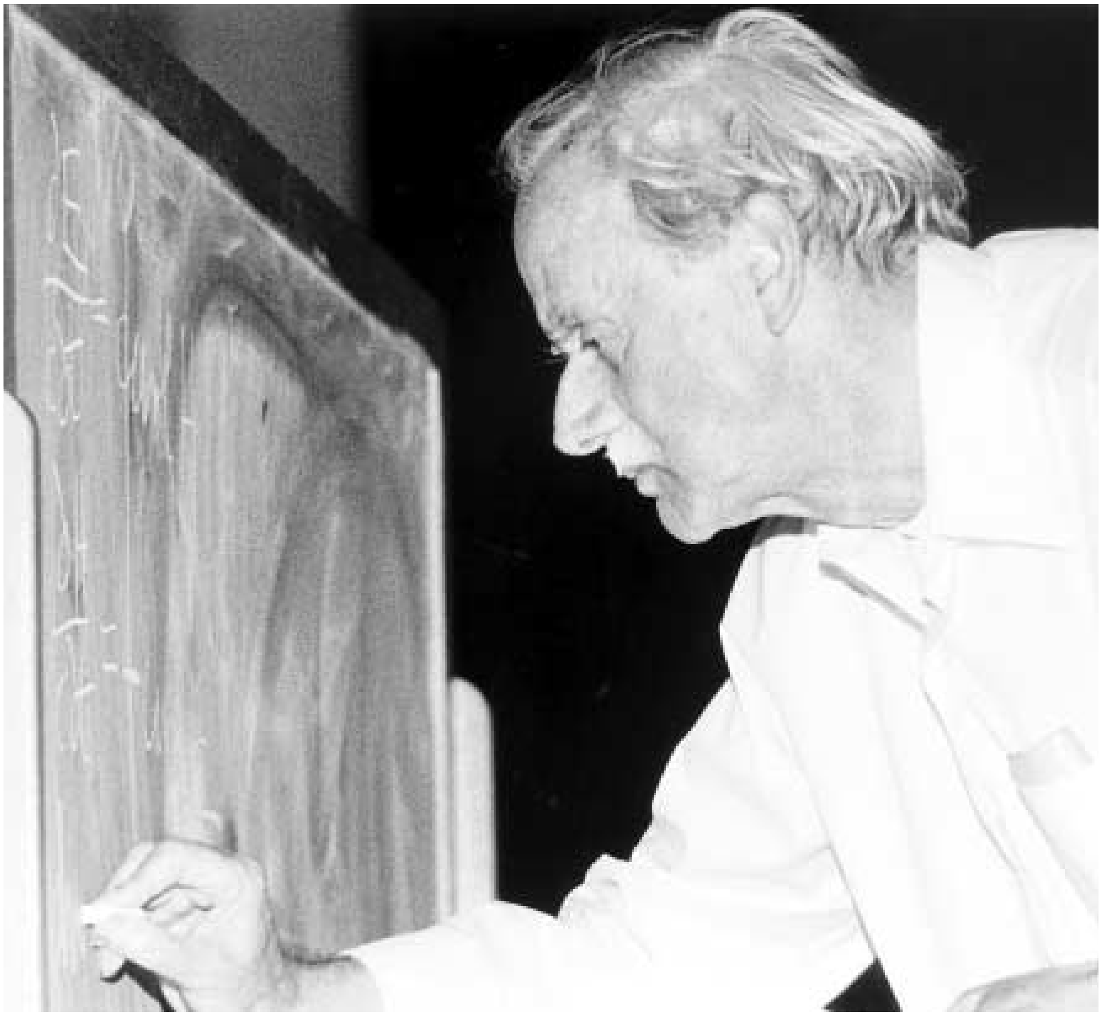
Higgs comes burdened with difficulties of its own. Happily, though, even those difficulties may be resolved by a theory known as supersymmetry.

The problem of introducing the Higgs into the Standard Model is symptomatic of a more general deficiency in an otherwise stunningly successful model. The Standard Model was designed to describe particle interactions at length scales of particles like the electron or the quarks. These, less than billionths of millimeters in size, are undoubtedly tiny, but are still far from zero. The problem with the Standard Model occurs when physicists try to understand particle interactions at length scales close to zero. At that point, infinite quantities pop up in the energies and masses of particles. Infinities are meaningless not only to physics, but also to common sense; it is impossible to have a particle with an infinite mass, for example.

Sometimes, the Standard Model can take care of these infinities by a process called renormalization: getting the infinite quantity to cancel out with some other infinite quantity with an opposite sign. Most of the Standard Model particles are prevented from being infinitely massive by having some sort of symmetry; these symmetries are restrictions on how they behave and interact with each other. Unfortunately, the Higgs boson has no such symmetry to slim it down, and it gets heavier and heavier as the Standard Model is called upon to explain physics at smaller and smaller length scales.

The easiest way for theorists to stop the out-of-control growth of the Higgs was to introduce a symmetry, and supersymmetry was the one they chose to cure the Higgs's weight problem. Developed about 20 years ago, supersymmetry proposed giving the Higgs a partner—a supersymmetric partner called the Higgsino—identical to it in every way except for its spin. The Higgsino could then act as a sort of personal trainer to the Higgs, not allowing it to do things that made it too massive, and keeping it nice and lean to be of service to the Standard Model.

But supersymmetry and the Higgsino came along with much excess baggage. Not only was there a supersymmetric partner for the Higgs, there had to be supersymmetric partners for all other particles. All these new supersymmetric partners would have exactly the same properties as their twins, again with the exception of spin.



Fermilab Archives

Theorists have invented particle partners before. In the 1930s, to reconcile quantum mechanics with relativity, Paul Dirac proposed siblings for all known particles, identical to the existing particles in every way but with opposite charges. The mysterious siblings—antimatter—are now as commonplace as they were once exotic.

Spartners for all

Physicists have had their share of fun in naming the supersymmetric particles. Some get an "s" put in front of their ordinary names, the sypersymmetric partner (or spartner) of the electron is the selectron, that of the quark is the squark. Other particles, like the Higgs, get suffixed by an "ino": the spartner of the photon is the photino, that of the gluon is the gluino, and so on. In essence, supersymmetry claims, we have only seen half the particles that exist. The rest are lurking in the wings, waiting to be discovered.

Stupendous as this may sound, there has been a precedent, points out Fermilab physicist Joe Lykken. In the 1930s, when trying to reconcile quantum mechanics with relativity, Paul Dirac found that, for his theory to make sense, all known particles had to have siblings. These siblings were identical to the existing particles in every way, except that they had opposite charges. The mysterious siblings—antimatter—were soon found. They are now as commonplace as they were once exotic and have been snugly accommodated into particle physics.

The spartners, however, have been much more elusive. It was clear from the very beginning that any particles with the same mass and charge of everyday electrons and quarks would already have been found. As no such particles have turned up, supersymmetry is said to be a broken symmetry. Something has caused the masses of the spartners to be very different from the regular particles. In fact, such a symmetry breaking happens quite naturally in the theory at extremely high energies, energies beyond the realm of even the most powerful particle accelerator imaginable. But even though the pairs of particles are split apart and given different masses at high energies, they must have a way of communicating that information down to the more earthly scales that are accessible to us. How exactly this communication might take place is not well understood. One possibility is gravity. Another is that the interaction might occur through some new particle, one similar to the photon or the gauge bosons that fly back and forth to carry the weak force.

…Any particles with the same mass and charge of everyday electrons and quarks would already have been found. As no such particles have turned up, supersymmetry is said to be a broken symmetry.

They can't hide forever

However supersymmetry breaking transmits itself to our world, the result is that if the spartners were to be hunted down in particle accelerators they would be quite heavy. Supersymmetry does not predict exact masses for the various squarks and sleptons. Thus, there is no need to panic and abandon the theory because none of the spartners have yet been found. If they do exist, though, they cannot keep hiding forever. Although there is theoretically no limit on how heavy the spartners can get, after a certain point they no longer perform the function for which they were originally invoked. After all, the supersymmetric particles were supposed to prevent the Higgs from getting too hefty, but if they themselves are not trim enough, their existence serves no purpose. There is a sort of natural mass range within which they are expected to be found.

Tantalizingly, the current generation of particle accelerators is just at the edge of that expected range. At Fermilab, the hunt for sparticles is already on. There are dozens of different ways in which these sparticles can make their presence known to experimenters, depending on exactly how supersymmetry theory is formulated. All sparticles, except perhaps the lightest one, are unstable; they decay either into other sparticles or into the regular quarks and leptons that we already know. If they decay into particles of the ordinary kind, it could be extremely difficult to confirm that they were indeed produced from supersymmetry and not from some known Standard Model process. Some signatures — the presence of lots of electrons and muons in the detector, for example — would be clear indications of a sparticle decay because they are not produced in copious quantities by any other known process. Heavy sparticles can also decay into a chain of lighter sparticles, the lightest of which would then be stable. This lightest supersymmetric particle (LSP), theorists have determined, would be neutral and extremely reluctant to interact with any kind of matter at all, much like the slippery neutrino. So the only way it could be detected is by comparing the energy before a particle decays with the energy after. Missing energy could mean that the elusive LSP has zipped off into space, carrying the missing energy with it.

Maria Spiropulu, a Harvard University graduate student doing her thesis research at Fermilab, is hot on the trail of the LSP, searching for this missing energy. The search is painstaking because it is crucial to determine that some other process does not account for the missing energy; only then can it be attributed to the LSP. Like all particle searches, this one requires combing through staggering amounts of data. And sparticle hunters must peruse not just experimental data from particle collisions. Numerous computer simulations are run of what might possibly be happening in the accelerator. The expected angles at which particles emerge are calculated—their energies determined—and every imaginable scenario played out. Slowly but surely, Maria and her colleagues map out mass regions where the LSP has definitely not been found, so that future experiments will have a better idea of where to look for it.

If the LSP is found, it will not only be particle physicists who start popping bottles of bubbly. Cosmologists would eagerly join in the celebration, because the LSP is the perfect candidate for their postulated dark matter, the mysterious stuff that must make up most of the matter in the universe for gravity to act as it does. String theorists, who view all particles as being tiny, extended stringlike objects instead

Photo by Jenny Mullins

Harvard graduate student and CDF collaborator Maria Spiropulu, whose e-mail address is "smaria," is tracking supersymmetry by looking for energy that's missing from particle collisions.

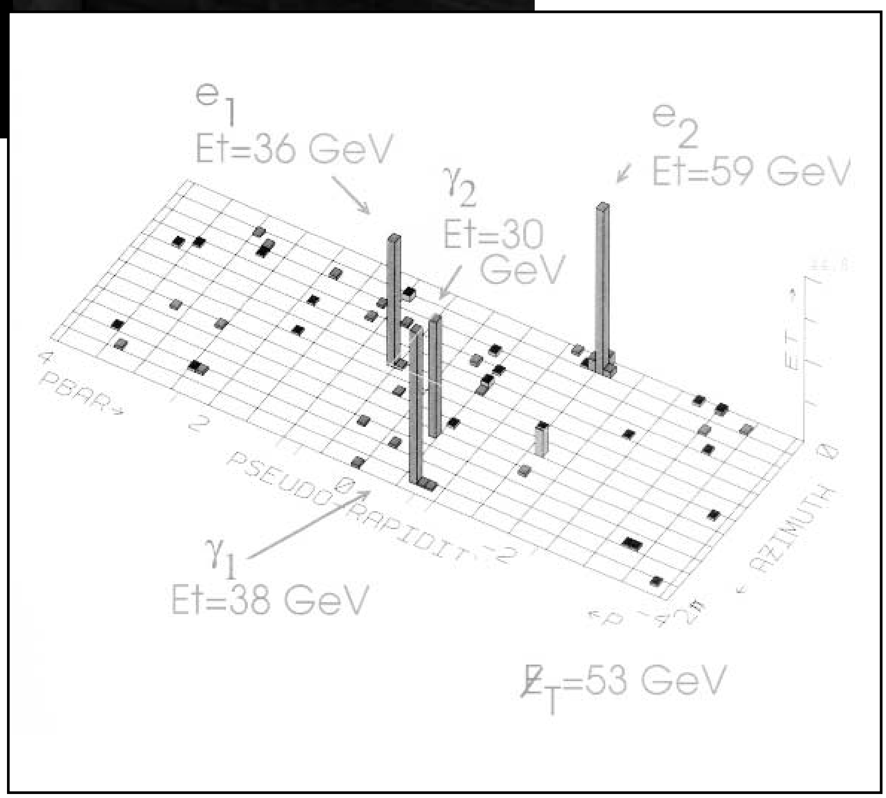
Photo by Fred Ullrich

Fermilab theorists Marcella Carena and Joe Lykken (not shown) organized the first in a series of workshops at Fermilab on the physics of Run II, devoted to supersymmetry.

of points, would also be thrilled if supersymmetry were vindicated. String theory is so far the best “theory of everything” to describe all the particles and forces of nature, including gravity, but it is exceedingly difficult to test because strings exist at unimaginably high energies. But string theory predicts supersymmetry, so sparticle discovery would be encouraging. Moreover, knowing the masses of the sparticles might reveal more about what string theory should look like and even lead to more direct experimental tests.

Within the next decade, if not the Tevatron then the Large Hadron Collider should be sufficiently powerful to find strong evidence for either the LSP or other signs of supersymmetry. And if no sparticles are found, at the very least those experiments will tell physicists that all is not well with their existing ideas of how the theory is fabricated. A null result would point to new ways of thinking about exactly how particles get mass. The great thing about supersymmetry, says Fermilab physicist David Stuart, is not just that it works in theory, but that it makes predictions that can actually be tested in real life. ■

Meher Antia is a freelance writer.



Theorists are alert, to say the least, for the slightest experimental evidence for supersymmetry. This CDF particle collision event made theorists’ hearts beat faster when it appeared in 1995. Although the event has still not been explained, many believe that it may not represent the first experimental hint of supersymmetry. If it did, they say, similar events should have shown up by now at CERN’s LEP collider.

Photos by Reidar Hahn

At the Supersymmetry/Higgs Workshop (left to right): Pran Nath, of Northeastern University, Ian Hinchliffe, of Berkeley Lab, and Brig Williams, of CDF and the University of Pennsylvania.

Beating a Path to Supersymmetry

Experimenters and theorists are plotting strategies for nailing sparticles and bosons in Run II.

by Sharon Butler, Office of Public Affairs

Gordon Kane, a theoretical physicist from the University of Michigan, has no doubt that the ever-hypothesized, never-materialized supersymmetric partners of quarks and leptons will be produced when the Tevatron begins operating again in 2000. And so will the Higgs, that elusive particle that theorists think is responsible for conferring mass.

But whether they'll be detected is another matter.

And that's why Fermilab held in May the first in a series of meetings of the Supersymmetry / Higgs Workshop: to begin mapping out a detailed and realistic strategy for Run II for discovering sparticles, as the hypothetical supersymmetric particles are called, and the Higgs boson.

Like other physicists, Kane, a champion of supersymmetry, is convinced that, once the Main Injector is ready and the Tevatron cranks up again, these long awaited particles can be discovered at Fermilab. The upgraded accelerator will be operating with a center-of-mass energy of 2 TeV and an integrated luminosity 20 times that of the previous run. As a consequence, the Tevatron will be able to generate a sufficient number of particles in the lower end of the energy zone (about 100 GeV) where sparticles and the Higgs might reside. Of course, the Large Hadron Collider, now under design and development at CERN, will be a full-fledged sparticle and Higgs factory and detection should not be too difficult, but the first glimpses might be had right here in Batavia.

Kane, though, in his opening talk at the May meeting, was blunt: Even if these particles are produced, detecting them won't be easy. "[The signals] are never clear, obvious, or easy to interpret," he said.

CRITICAL PATH

That much was apparent from the variety of presentations by five working groups of the workshop, all aimed at divining the multiple possible ways sparticles and the Higgs might be produced in the Tevatron and might decay. From those profiles, the speakers tried to suggest how the hoped-for particles might show themselves: that is, the kinds of electronic "signatures" experimenters could look for to distinguish the newcomers from the usual Standard Model particles.

From Howard Haber, of the University of California at Santa Cruz, came predictions of a relatively light Higgs, with less than three-quarters of the mass of the top quark—still more theoretical support for the assertions of Kane and others that the Higgs is within the Tevatron's new reach. And John Hobbs, of Fermilab's DZero collaboration, described a combined analysis of multiple signatures, which would increase chances of a Higgs discovery.

The working groups on supersymmetry described work to date on the possible signatures of sparticles, whether derived from popular supersymmetry models like supergravity or gauge mediation or from more exotic models like those derived from string theory. Greg Landsberg, of DZero, and Ray Culbertson and Teruki Kamon, both of the CDF collaboration, offered novel strategies for taking advantage of upgrades in Fermilab's two main detectors to pin down supersymmetry.

If supersymmetric particles exist, life—or at least particle physics—would make more sense. Much hangs on them. They allow the unification of the gauge model of the four forces. They provide a mechanism for the Higgs boson to break the symmetry of the electroweak force. They would give us identifiable candidates for cold dark matter. And they would help us explain—because the theory of supersymmetry predicts—the heaviness of the top quark, far out of line with the masses of the other quarks.

Already, supersymmetry plays a crucial role in explaining phenomena as wide-ranging as cosmological inflation and proton decay, even though no experimental evidence has yet been found to prove that supersymmetry is right.

In sum, then, what's inspiring all the excitement and hard thinking evident at the May meeting is the great explanatory power of these particles, and the chance to lay claim to a discovery that, as speaker David Gross, director of the Institute for Theoretical Physics, put it, would push physics past the Standard Model and open the door to a truly fundamental understanding of matter, space and time. ■

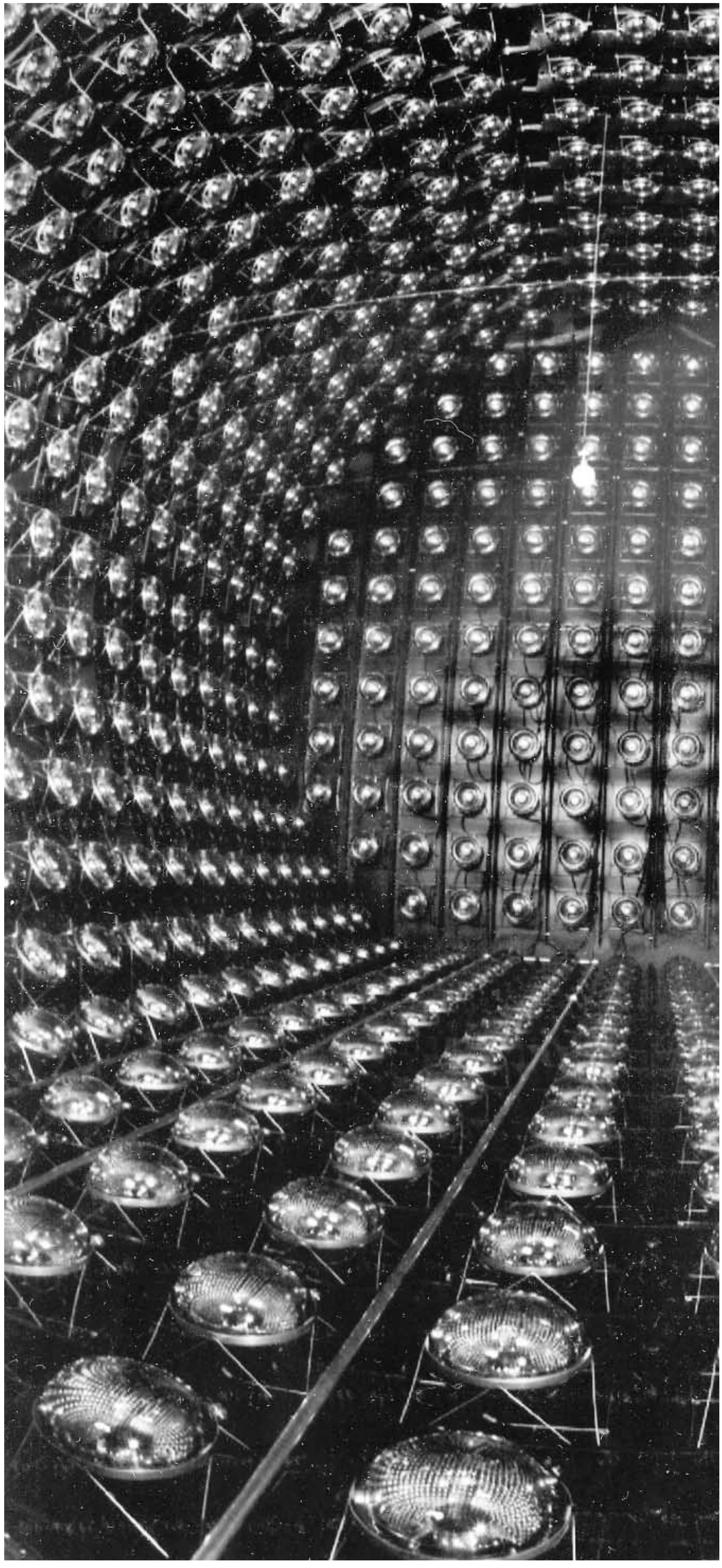
MiniBooNE Faces the PAC

by Sharon Butler, Office of Public Affairs

The story so far:

MiniBooNE is a proposal hoping to be an experiment, with collaborating scientists eager to prove or disprove a controversial signal in the liquid scintillation neutrino detector at Los Alamos National Laboratory, a signal that could be evidence of neutrino oscillation.

MiniBooNE has been proposed to the Physics Advisory Council before, but experiments are never approved the first time around. Hopes are high for approval at the committee's May 15 meeting.



More than 1,000 phototubes from Los Alamos's liquid scintillation neutrino detector will be used again in the MiniBooNE experiment, saving time and money.

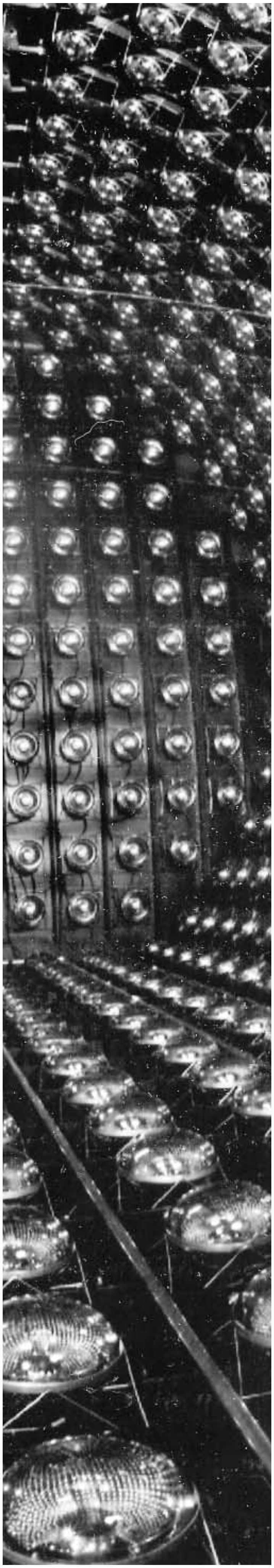


Photo courtesy of Los Alamos National Laboratory

Thursday, May 14

The MiniBooNE collaboration crowds into a conference room at Fermilab. Countdown. The presentation before the Physics Advisory Committee (PAC) is just a day away. Twenty-four hours until the fate of MiniBooNE is decided.

Janet Conrad and Bill Louis, the cospokespersons of the proposed experiment, deliver their practice talks. They have lots to do in the allotted 25 minutes, and they wonder whether they can squeeze it all in. They have to remind the PAC what MiniBooNE is all about: a promise of big physics in a small package. They also have to update the PAC. Specifically: The Los Alamos group has completed its analysis of data obtained between 1993 and 1997, no change in results from the earlier data set; the signal is still there. Also, it seems the Karmen 2 experiment in Great Britain won't be able to disprove the results from the liquid scintillation neutrino detector (LSND) at Los Alamos. Experimenters there expect to get only two to eight events, with a background of 7.6 events. Bottom line: only MiniBooNE can set to rest the controversy over the LSND measurements.

Friday May 15

Panic at the PAC meeting.

There's supposed to be a half-hour break just before the MiniBooNE presentation, when the collaboration plans to set up its *piéce de résistance*, a simulated computer display of neutrino events, in three dimensions and in color. But the PAC decides to cut the break to just 15 minutes. Geoff Mills, from the collaboration, and Jeff Kallenbach, from the Computing Division, scramble to get things ready.

Another tense moment: Conrad finishes her talk and is about to unveil the event display. She presses the button on the computer. Nothing. She presses the button again (unwittingly turning it off). Nothing. There's a buzz in the room. Conrad doesn't have any backup slides. She takes a deep breath, presses the button once more (patience), and this time the events appear, finally, in glorious dancing colors.

At the end, the audience breaks into unexpected, and somewhat embarrassed, applause. No one has ever heard applause at a PAC meeting before. Some say it was PAC member Giorgio Belletini who clapped first—carried away by Conrad's enthusiasm.

That evening, at the traditional dinner at Chez Leon, in Fermilab's Users' Center, Taiji Yamanouchi, assistant director for program planning, pads over to Louis and Conrad. He quietly hands them a list of questions from the PAC, which they are supposed to answer at the followup session Saturday. Yamanouchi enquires whether they would be able to meet with the PAC at 10:30 Saturday morning (Yamanouchi always asks; presenters would never think of declining).

The scientists in the MiniBooNE collaboration are waiting in the wings in case they have to crunch numbers late into the night, but the questions concern funding, for which the homework is already done. The collaborators call it a day; Louis and Conrad enjoy their desserts at Chez Leon, guilt free.

Saturday, May 16

The PAC deliberates.

Since MiniBooNE aims to confirm or refute the LSND experiment, the PAC spends considerable time discussing the original results. The PAC is impressed with MiniBooNE. Its documents are all well written (Conrad has her sister, an English teacher, proof them). Its presentations are "among the clearest and best organized" and "no one comes close to Conrad's effervescence," says Andreas Kronfeld. The PAC decides that MiniBooNE, unlike any other experiment anywhere in the world, can definitively prove or disprove the LSND measurements.

The PAC makes its recommendations to John Peoples, Director of Fermilab, who will add his own comments in the formal letter that will be sent to the collaboration.

Sunday, May 17

Everyone in MiniBooNE is on tenterhooks.

Monday, May 18

Conrad arranges to "bump" into Peoples at lunchtime in the Fermilab cafeteria. Peoples tells her the good news: MiniBooNE has scientific approval. The show can begin.

Conrad rushes to the phone to call Louis and Mike Shaevitz, her colleague at Columbia University.

Louis's first reaction: euphoria. But then a "hard (but not unpleasant)" realization: now we have to build MiniBooNE. He e-mails the entire collaboration.

Scientists in the group at Los Alamos celebrate with lunch at the Blue Window and bottles of Sierra Nevada Pale Ale.

Randy Johnson, a member of the collaboration at the University of Cincinnati, is now "on Cloud 9." He has a stack of MiniBooNE proposals in his office and hands them out to anyone who stops by.

Byron Roe, another collaborator, at the University of Michigan, is cool. He remembers how Enrico Fermi once advised selecting an experiment. Estimate the level of interest there would be in the result, and then the likelihood of getting that result, and take the product of the two. The product for MiniBooNE, Roe long ago figured, is pretty high.

All Conrad can think of now is what Fermilab physicist Jeff Appel told her after the PAC presentation. He said that when people clapped, she should have responded, "No applause, please. Just send money."

Which takes us to the next installment of our series on the MiniBooNE experiment: the quest for funding. ■

The Line on Fishing at Fermilab

Careful tending helps still waters yield deep enjoyment.

A 1996 fish survey turned up nearly a dozen species of fish in Fermilab's ponds.

by Mike Perricone, Office of Public Affairs

It is the most tranquil of sports, sometimes practiced from the comfort of a folding chair, occasionally from the comfort of slumber, in the early mornings before the day has begun making its demands.

A drawing back of the arm, a flick of the wrist, a transfer of momentum to a graceful curve of the unreeling line, a small splash as hook, weight and bait enter the water, then a quiet wait, long or brief, for a bite or for a repeating of the purposefully slow and satisfying rhythm of another casting of the line.

"There's been fishing at the Lab about as long as there's been a Lab," said Dave Shemanske of Facilities Engineering Services.

The Lab has seven ponds that were integrated into the cooling system for the accelerator operation. Robert Wilson, the Lab's original Director, designed the system to augment the natural appeal of 6,800 acres largely given over to open land and restored prairie.

"There's fishing here every day, even through the winter," said Shemanske, who looks after the Lab's pond system with an almost personal regard. "Swan Lake is a major cooling pond, receiving water warmed by the magnets. So the fish are feeding there all winter long, while other places freeze up. You'll even see a lot of people coming out at lunch time."

The fish population, fed by an access pipe to the Fox River, is large and diverse. A 1996 population survey of six ponds by the Illinois Department of Natural Resources turned up nearly a dozen species of fish, from largemouth and smallmouth bass to bluegill and channel catfish, and on to rough or "junk" fish like carp and shad. There were nine species in Casey's Pond alone.

Improving and extending the fish population has been a continuing focus; former director Leon Lederman even used personal funds to help stock the ponds. Shemanske, Kalina, Doug Arends and others in the Ecological Land Management Committee (which extends to other divisions and sections as well as off-site organizations), have been following the recommendations of Rob Miller, the Dept. of Natural Resources biologist who conducted the survey.

They've created shelters to help protect spawning game fish, particularly the largemouth and smallmouth bass, from the intrusions of rough fish, whose habits can result in silting over nesting areas and suffocating eggs. They've created spawning baskets, used pallets to create shelters, sunk ceramic pipe to simulate hollowed-out tree trunks, even lugged Christmas trees out to the center of frozen-over ponds, weighted them with cinderblock, and allowed them to sink to the bottom in the spring thaw.

The Lab's bird population is also large, equally diverse and growing, ranging from robins to turkey vultures, the ubiquitous geese and ducks, and the graceful egrets and herons. Kalina said a turkey ("and it's a pretty big one") has even been sighted recently.

Yet fishing—actually, fisherman—can pose an inadvertent threat to the Lab's abundant birdlife. Fishing line that's tossed aside can be especially treacherous.

"Fishing line doesn't break down very easily," said Jim Kalina of FESS. "It could be here for a hundred years, for all we know. But birds see a big ball of fishing line lying around and think it's nesting material. They try to use it and get all tangled up. They can get it wound around their legs, or they can easily get hung up in a tree."

Geese are especially vulnerable to fishing line tangles.

"If you see geese limping around, that's the problem right there," Kalina said. "They've gotten fishing line wrapped around a leg. The circulation is cut off, and gangrene can set in. They can still fly, but they're so weak, by the time we finally catch them, it can be too late. I've even seen two birds wrapped in fishing line, where one is trying to fly and the other is trying to break away. Fishing line lasts forever."

Shemanske said "every effort is made to try to save every animal who seems to be wounded." Kalina takes injured animals, including birds, to a wildlife rehabilitation center in nearby Willowbrook, where volunteers nurse the animals back to health if possible. Kalina would like to have fewer patients.

"We want to make it better for everybody," he said. "Enjoy what's here, but respect it. That's the message we want to get out." ■

Photo by Reidar Hahn

Don’t Cast Trash!

Illinois fishing rules apply at the Lab, so you’ll need a license if you’re 16 or older. Representatives of the Illinois Department of Natural Resources are on site regularly to check licenses.

Some additional suggestions while you’re fishing:

- Be especially careful to pick up all hooks, bobbers and fishing line.
- Don’t leave bait cups or bait canisters behind; they attract raccoons.
- Observe wildlife but don’t interact with it.
- Avoid nesting areas; if you disturb a duck or goose in a grassy area, you’ve probably encountered a nesting female.
- Dogs must be kept on leashes, except for the designated dog run area.
- Make sure children stay close to adults.

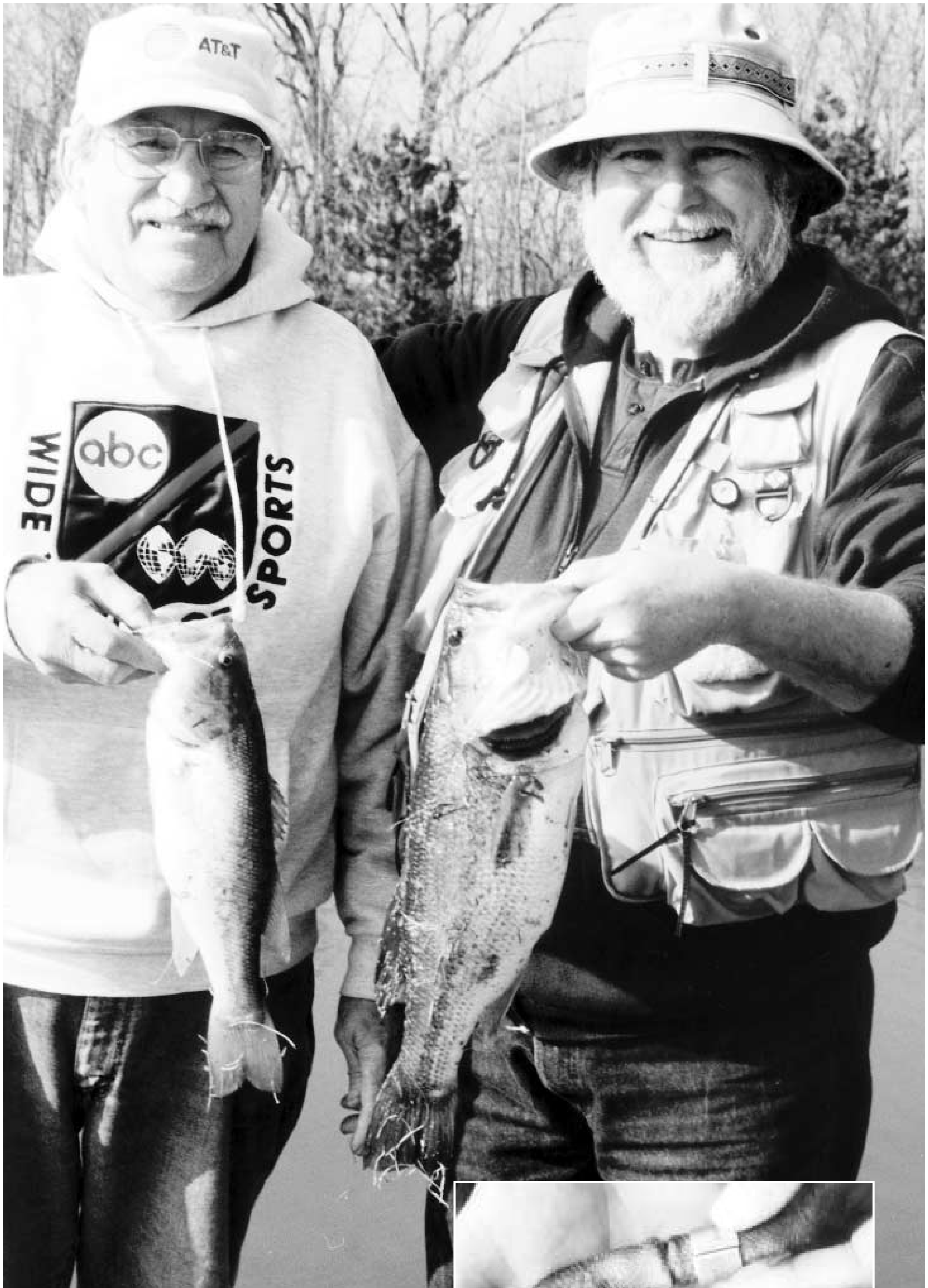


Photo by Jenny Mullins

Fishing is a year-round activity with year-round rewards at Fermilab. Pete Snolpko (left), of the Village of Wayne, holds a 12-inch widemouth bass, while Paul Lesko’s catch runs 18 inches.

Photo by Mike Becker

Fishing line can become wound around a goose’s leg, cutting off circulation. Fortunately, this goose was helped in time to save it from serious injury. The metal band is an identification tag placed by biologists.

The Paper Chase Goes Paperless... *Mostly*

On-line preprints save time, space and money, but paper keeps hanging on

by Mike Perricone, Office of Public Affairs

With an overnight change in January 1998 that was more than four years in the making, Fermilab's Information Resources Department formally completed its electronic transformation and stopped the monthly mailing of preprints, the drafts of articles that physicists circulate while awaiting acceptance from scientific journals.

The result: $175,000 in annual savings, including $92,000 in postage and $78,500 in duplicating costs. The transformation—and the savings—grew from the work of the Publications File Server Project, a collaboration between the Computing Division and the Laboratory Services Section going back to 1993.

"With the huge amount of money spent on electronics these days, it's hard in many cases to see the payoff," said Steve Wolbers, Deputy Head of the Computing Division and an original project member. "This one is pretty darn clear."

"In 1990, we were mailing out almost a thousand copies of each preprint and conference paper each month," said Cindy Crego, manager of Information Resources, which includes the Office of Publications and the library. "Now, we don't have to deal with handling and storing those large amounts of paper. Yet the information is available 24 hours a day, seven days a week."

Preprints, conference papers and less-formally written technical memos and physics notes, are organized and stored on a Fermilab file server; they are also indexed in the Fermilab library on-line catalog. Only four paper copies are mailed each month, accommodating special requests.

"People are beginning to ask us what we're doing and how we've accomplished what we have," said Wolbers. "We've become kind of a model for other labs, which is surprising, because I'd say we were in last place not so many years ago."

Of course, there's still room for paper. Physicist Liz Buckley-Geer, an original project member, said she prefers a paper copy for reading and making notes. Theoretical physicist Stephen Parke, not a project member but a steady proponent of electronic preprints, reads his copies on paper and called the paperback book ideal because "it can be taken almost anywhere, though probably not in the shower."

"It's a lot easier to manage information by making electronic links than it is to deal with all the paper," said library administrator Sara Tompson. "We provide information by computer just when people need it, instead of putting it on the shelves just in case someone wants it."

Photo Jenny Mu

And the savings have created costs in some unexpected areas. Tompson has seen increased use of toner and paper for the library's newly added public Postscript printer since preprints went electronic.

"People are printing out a gazillion things," she said. "At $120 a pop, toner isn't cheap, and we go through a lot of it."

"Printing out a document on a laser printer is a lot more expensive than duplicating a copy," said Fred Ullrich, who tracks the Lab's copiers as head of Visual Media Services (VMS). "We may be moving (documents) off the official volume listing, but they're still being printed out. The Lab averages about 2.1 cents for a duplicated copy, but you're approaching five to 10 cents apiece on a laser printer."

Crego pointed out that laser print-outs are for individual copies, not long printing runs. Buckley-Geer stressed the difference between printing out a single copy and looking over stacks of paper collected just in case they are needed.

"Sometimes a title can be really attractive, but you start reading it on the computer and see that it's quite hopeless," she said. "So at least you haven't wasted a tree by printing it out."

Ullrich noted that while overall paper use is down at the Lab, duplicating services are as busy as ever. Crego explained that the project's goal was not specifically eliminating paper, but storing and distributing information efficiently.

Physicists have consistently taken the lead in circulating information quickly. The World Wide Web was developed in 1991-92 by Tim Berners-Lee and colleagues at CERN, the European Particle Accelerator Laboratory, so that physicists could quickly and easily share data. Paul Kunz adapted the software for the first U.S. Web site at SLAC, Stanford Linear Accelerator Center, site of the widely-used SPIRES-HEP (Stanford Public Information Retrieval System-High Energy Physics) search engine. Theoretical physicist Paul Ginsparg built a system at Los Alamos National Laboratory that has grown into the file server of choice for many physicists.

"Also around that time, Joanne Cohn, a postdoc at Fermilab, was sort of a human archive (at the Lab)," said theorist Andreas Kronfeld. "People would e-mail her their papers, and she would e-mail them out to people who might be interested or asked to be on her mailing list."

Kronfeld said the Los Alamos server is the preferred preprint destination for his papers and those of many other theorists because "that's where people will look for them."

"It's good to have a server at Fermilab," he said, "but why do I have to submit to both? Why can't it be set up electronically, so if submit to one, it also goes to the other?"

However, astrophysicist Rocky Kolb doesn't regard Fermilab's server as competition for Los Alamos.

"I suspect if my friends and colleagues wake up in the morning and say, 'Gee, I wonder what Rocky's done lately,' they would go to Los Alamos rather than to the Fermilab file server," Kolb said. "But the work of our (Astrophysics) group goes to the Fermilab server. You want to have a record of what we produce at Fermilab—knowledge. That's our product. We want to be able to point to it, and package it, and allow people to get at it."

When preprints are submitted to Publications, technical editor Jean Slisz goes to work. Documents are submitted in PostScript format, common for scientific documents. Slisz translates the documents into formats that are easier to read and consume less storage space. She "glues on" an electronic title page, including the Fermilab preprint number, title, author and affiliation, to identify the paper's source.

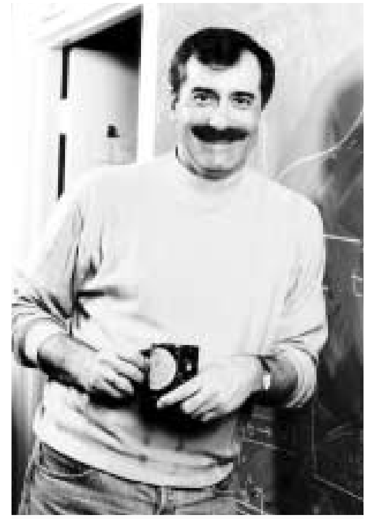
The Web page for the Publications file server also includes experiment proposals and Ph.D. theses. "Legacy" documents, papers originating before 1995, eventually will be scanned and stored electronically; a proposal calls for an outside vendor to create CD-ROMs at a cost of $70,000 to complete the compilation.

"With our project, for work at Fermilab, we're able to collect and archive information from cradle to grave," said Crego.

Under rules from the Department of Energy and the National Archives, one paper copy of each technical report is maintained here for the life of the Lab. But physics-wide archiving is far from settled. "The American Physical Society is starting to think about archiving all this stuff," said Tompson. "But who has that responsibility now? Can we trust someone's server to be up forever?"

Eternity aside, systems like the Publications file server provide fast, convenient, and even egalitarian information access.

"If I put a paper on the Web today," said Parke, "anybody in the world with computer technology can download it tomorrow. You don't have to be at the best institutions to get the first copy of a preprint, as you did in the past. It's a great equalizer." ■



"Imagine that only a few years ago, the printing press had just been invented," said Rocky Kolb. "Imagine the questions: What are books? How are they bound? What are libraries? How is information disseminated? What is a copyright? What constitutes actual publication? People are groping their way toward a new world."

Photos by Reidar Hahn

"Sometimes a title can be really attractive, but you start reading it on the computer and see that it's quite hopeless," said Liz Buckley-Geer. "So at least you haven't wasted a tree by printing it out."

CDF Turns 20

On May 20, CDF turned 20, celebrating the occasion with a day of talks on the birth and development of the collaboration and a night of food and fun.

Alvin Tollestrup, the first spokesperson of CDF, blows out the candles on the collaboration's birthday cake.

John Cooper, head of the Particle Physics Division, likened aspects of the CDF detector's operation to the four horsemen of the Apocalypse. From the foreground: Death, "how we all feel on owl shift"; Famine, "when you've got no beam"; War, a few flared tempers among collaborators; and Pestilence, the occasional rabbit, a cat, and, once after a flood, a fish in the collision hall.

Photos by Jenny Mullins

Physicists John Yoh and Cathy Newman-Holmes (above); CDF "housemother" Dee Hahn and Particle Physics Division Head John Cooper (below).

Chez Léon

MENU

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

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

Lunch Wednesday June 10

Pasta Salad with Shrimp,
Red Peppers and Black Olives
Cantaloupe with Berries

Dinner Thursday June 11

Scallop Salad with
New Potatoes
in Creamy Vinaigrette
Pork Tenderloin Scaloppini
with Citrus Balsamic Sauce
Green Beans with Onions
Tomatoes and Dill
Orange Cake with
Grand Marnier Sauce

Lunch Wednesday June 17

Quesadillas
with Cheese and Beans
Jicama, Carrot, Black Olive
and Tomato Salad
Tropical Fruit Platter

Dinner Thursday June 18

Melon and Prosciutto
Filet of Sole
with Crabmeat Stuffing
Parsley Rice
Vegetable of the Season
Strawberry Shortcake

CALENDAR

JUNE 7

Fermilab Barnstormers Radio Control Model Club hosts a 1/4 scale fun fly at 9 a.m. through the late afternoon. Some of the best radio control pilots in the midwest will bring their large scale models to perform amazing aero-antics. Refreshments available. For further information, contact Alan Hahn, x2987.

JUNE 10

Health Fair from 11 - 2:00 p.m. in the Atrium, Wilson Hall. The Fair has expanded to include 20 exhibitors: Hospitals, Clinics, Health Care & Community Service providers. There will be screenings, assessments, demonstrations, massage therapy, prizes & give aways. Participants may enter to win raffle prizes which include: a portable CD player, an AM/FM headphone radio, a massage therapy session and numerous other prizes.

JUNE 12

Fermilab International Film Society presents: *Olivier, Olivier* Dir: Agnieszka Holland, FRANCE (1991). Admission $4, in Ramsey Auditorium, Wilson Hall at 8 p.m. For more information (630) 840-8000 or http://www.fnal.gov/culture/film_society.html.

JUNE 13 & 14

Fermilab Barnstormers Radio Control Model Club hosting the 9th annual Anthony Frelo Memorial Helicopter Fly-In. Everyone is invited. Pilots of all skill levels are encouraged to participate, with everything from trainers to scale models. Factory reps will be on hand for demos and advice. Reps from Lite Machines, who manufacture the LMH-100, a small & inexpensive helicopter, and Len Sabatto & Rick Hayes from JR Inc., are attending. Many championship winning flyers will demonstrate their fantastic flying abilities. Pilots must have Association of Model Aeronautics license. Spectators welcome. Refreshments available. For more info call Jim Zagel, x4076 or Alan Hahn, x2987. Guaranteed fun for all!

JUNE 14

Barn dance at the Village Barn from 7 to 10 p.m. Live music by The Hired Hands, with calling by Tony Scarimbolo. Dances are contras, squares, and circle. All dances are taught, and people of all ages & experience levels welcome. You don't need to come with a partner. Admission is $5.

Children under 12 are free. The barn dance is sponsored by the Fermilab Folk Club. For more info, contact Lynn Garren, x2061, or Dave Harding, x2971.

JUNE 22

Potluck Supper at Kuhn (Village) Barn. Drinks and appetizers at 6 p.m. Dinner at 6:30 sharp. Everybody either brings a main dish serving 6-8; or a dessert for 12; or contribute $3. Soft drinks provided, pizza for the kids and wine for adults. Babysitting is available. Questions? Call Angela Jöstlein (630) 355-8279.

JUNE 26

Golf outing at Villa Olivia Country Club. Tee-off times will start at 1:30 pm and a 1/2 day of approved Vacation is required to participate. Format will be 'Best Ball Scramble', so your team will use a combined handicap to determine prizes. Register soon to get an early Tee time! Cost is $35 for Golf and contests. Carts optional. For registration or more details contact Patrick Liston, x2332 or John Nadjzion, x2820 or Pg# 0988.

JUNE 27

Fermilab Art Series presents: *Tommy Makem with John Forster*, $16. Performance begins at 8 p.m., Ramsey Auditorium, Wilson Hall. For reservations or more information call (630) 840-ARTS.

ONGOING

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

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

For more information on events at Fermilab, see http://www.fnal.gov/faw/events.html.

FermiNews Essay Contest Results

As *FermiNews* went to press, one judge still remained to be heard from. Results in the next issue.

CLASSIFIEDS

FOR SALE

■ '84 Honda CJ 450 motorcycle, 5.6K miles, 6-spd. with overdrive, looks and runs like new. $1,000. John Scifers x2237 or scifers@fnal.gov.

■ '92 Lincoln Continental Signature Sedan, 87K miles, loaded 10 changer CD, moon roof, keyless entry, $8,000 obo. Greg Lawrence x3011 or (630) 557-2523.

■ '91 Honda Civic CX, 4 spd, hatchback, base model, metallic blue, blue / gray interior, AM / FM cassette, 1 owner, 76K, no rust, serviced by dealer, only premium gas, new exhaust & brakes, good tires, exc. cond. $4,800. Rafael, x8311, rafael@fnal.gov.

■ '88 Dodge Caravan SE, 135K (engine replaced at 80K) 3.0L V6,PS,PL. Newer tires, battery, fuel pump. Family van that has seen some wear. Very dependable, no rust. Would make excellent cargo or sports team transport. $2,500 obo. Contact Dane Skow, dane@fnal.gov or x4730.

■ '84 Black Corvette, glass top, 60K miles. New paint & tires. Very good running order, best offer. (630) 852-2475.

■ '75 VW Camper bus daily driver w / camping accessories. Pumpkin orange. $2,800 obo. Call Tom x6366. Garage-o-parts! Parts from '79 VW Bus, including seats, doors, trim, transmission, gauges, windows, etc. $150 takes everything! Boxes & boxes...call Tom, x6366.

■ Queen Size Sleeper Sofa with Serta Spring Bed. Excellent condition, like new, rarely used, $350. Call (630) 717-5181.

■ Large capacity Whirlpool electric dryer, $150; Maytag washer, $150. Both work well & reliably. Lynn Garren, x2061 or garren@fnal.gov.

■ Nordic Track exercise ski machine, hardly ever used $400.00 obo; Ski's - Atomic Arc 195, Salomon 547 Sport Bindings, size 12 US or 13 EU Trappeur 2000 boots also have poles, ski & boot bag, best offer. Call Terry x4572 or e-mail skweres@fnal.gov.

■ Golf Club Set: Ram Laser ZX, 3-PW, cast cavity backed; 1,3,5 metal woods steel shaft w / Lampkin tour grips, $325 obo; Call (847) 931-1235.

■ Trailer hitch for Chevy Astro van '88-'95, asking $50. Call Dave (630) 879-7398.

■ Dog Kennel 10'x10'x6' asking $125. Call Connie (815) 498-9594.

■ House - Elburn, 3 Bdrm, 1 Ba, large lot in town, 1-1 / 2 gar, well maintained, Many updates, Avail. immed., $125,900. (630) 365-2145.

RENT

■ Spacious 1 bdrm. apartment in St. Charles available end of June. AC, in building wash / dry, off-street parking, close to lab, heat included, quiet neighbors. Leo Bellantoni, x8772, bellanto@fnal.gov.

WANTED

■ Roommate wanted to share 3 bedroom house in west Aurora. $300 / mo plus half of utilities. Female, non-smoker preferred. No pets please. Call Lori, (630) 801-0306 and leave message.

■ Someone to carpool with from Indiana. I live in Hammond, the commute is about 1 hour 15 minutes. Jacob Foor x2698 or (219) 845-5683.

FRENCH LESSONS

■ Je suis française. J'enseigne le français. Peggy-Henriette Ploquin. (630) 682-9048.

LAB NOTES

Attention Fermilab Artists and Artisans:

Now is the time to show us your artistic side! The biannual Employee's Arts & Crafts Show will take place on the 2nd Floor Gallery of Wilson Hall, July 1-July 31. All Fermilab employees, visiting scientists, retired employees, contractors and their immediate families are encouraged to enter. The last exhibit featured, among other things, a wonderful mixture of photographs, prints, paintings, sculptures, weavings, quilts, and jewelry. Application forms for participating are available at the Wilson Hall Atrium desk. Application deadline is June 22, and exhibit drop-off is Monday, June 29.

Summer Recreation

For information on Fermi Coed Summer Volleyball, Basketball, Softball, and Soccer Leagues or Children's Swimming Lessons and Pool information, consult the Recreation web page: http: / / fnalpubs.fnal.gov / benedept / recreation / recreation.html

MILESTONES

BORN

■ [redacted] Lee (FESS / Engineering) & Karen [redacted]

MARRIED

■ Judy Cretens (FESS / Engineering) and John Teale on May 16. The couple is residing in Batavia.

RETIRING

■ Elaine Moore, PPD / Support Service Team, will retire June 30, her last working day will be June 17.

ELECTED

■ Theorist William Bardeen to the American Academy of Arts and Sciences.

LETTER TO THE EDITOR

A small technical point in the otherwise excellent article on Booster Digs by Mike Perricone (May 15, 1998) - if I may.

The kicker magnet used for extraction (like any other magnet) does not give a "jolt of energy." Only electric fields can give an energy increase to charged particles. The magnet merely deflects the particles, without changing their speed. It's like the magnets in our accelerator rings. These magnets simply bring the particles back to the rf cavities where the electric fields do the work of accelerating the particles, i.e., giving them jolts of energy.

Jeff Appel,

Particle Physics Division

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

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

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