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The All-W Edition

W boson mass measurements from Fermilab continued to set the world standard.
Water caused a problem for the Main Injector, but the
WBS kept
Work on track to bring that project down the home stretch.
We took a trip to the Office of High Energy and Nuclear Physics in
Washington.
We talked with Fermilab physicist Herman White.
Winter arrived at Fermilab with the year's first snowfall.
We send you, our readers, the All-W Issue, the final *FermiNews* edition of 1997,
With our best wishes to you all for a Wonderful New Year.

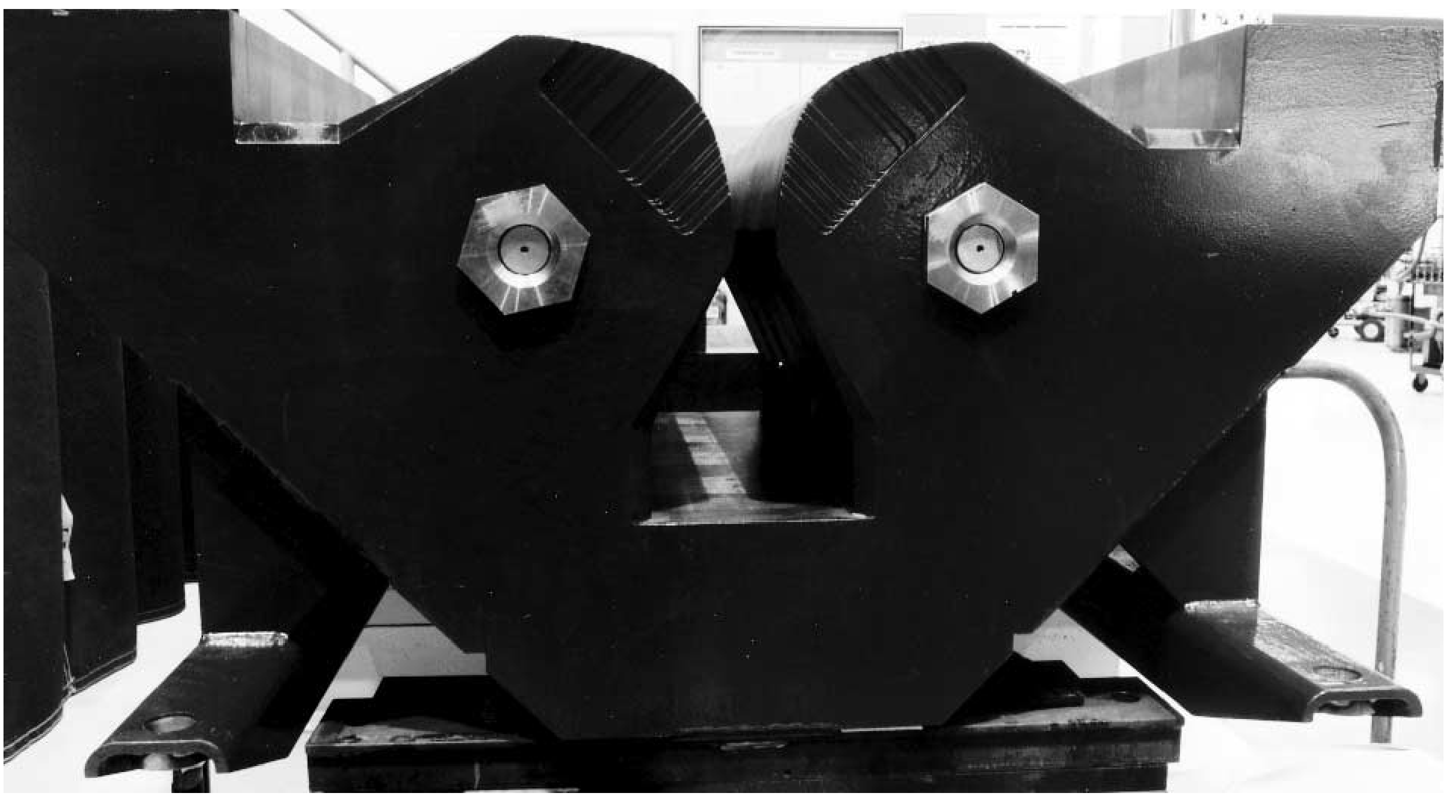


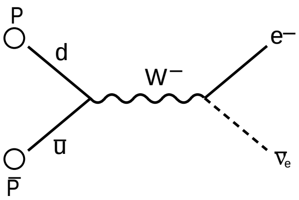
Photo by Jenny Mullins

Half core of a quadrupole magnet for the Accumulator upgrade.

The Wonderful *W* Boson

By Stéphane Keller, Fermilab Theory Group and Judy Jackson, Office of Public Affairs

The world's best measurement of the mass of the particle called the *W* boson comes from experiments at Fermilab's Tevatron. What is the *W* boson, and why do we care?



This Feynman diagram shows the production of a *W* boson from an interaction between a down and an antiup quark (produced by a proton and an antiproton, respectively) with the subsequent decay into an electron and its antineutrino.

When two elementary particles interact, they typically exchange a third particle called a boson, the carrier of the force acting between them. For example, when charged particles interact electromagnetically, they exchange the bosons known as photons. Photons are massless and can be easily observed in experiments: photons are the particles of light.

The range of a particle interaction—that is, the distance at which two particles can feel each other through the interaction—is inversely proportional to the mass of the carrier boson. If the mass of the boson is small, the range of the interaction is large. For the electromagnetic force the range is infinite because photons are massless.

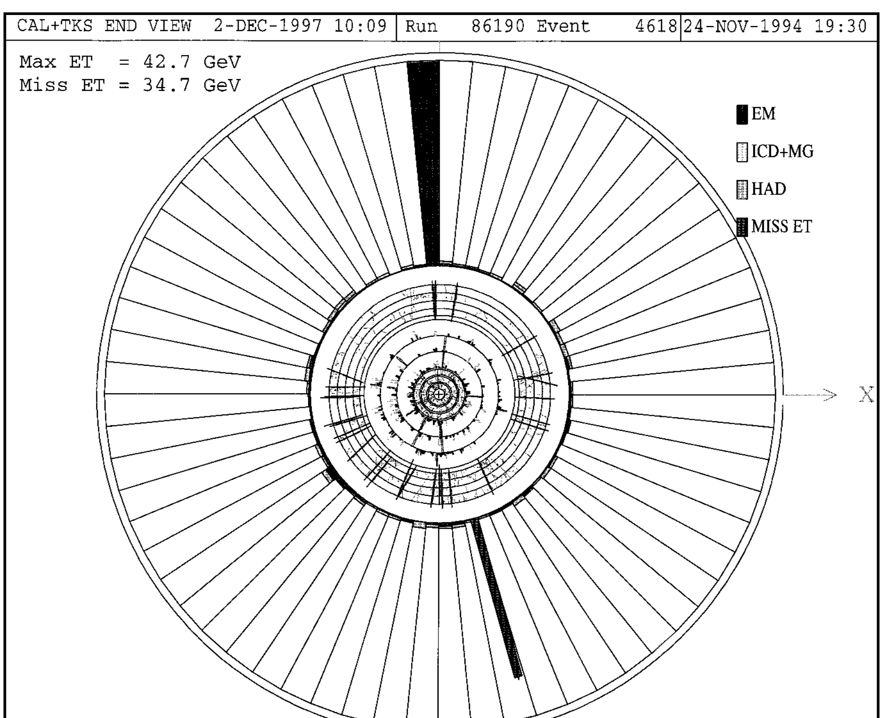
The *W* and *Z* bosons are the carriers for another type of force, the weak interaction, from which the *W* gets its name. (The *Z*'s name comes from its zero electrical charge.) The W is responsible for such phenomena as the emission of electrons by nuclei, known as nuclear beta decay. Despite its wimpy-sounding name, the weak interaction is very important for us here on Earth, points out CERN physicist Alain Blondel, because it is responsible for the main reaction that takes place in the sun.

"No *W*, no sun, no light, no life, no taxes, no Fermilab," says Blondel. "No CERN either."

But the existence of particle physics laboratories is only one reason the *W* holds great interest for particle physicists. The *W* also holds a key to understanding the critical issues of particle physics today.

"As the carrier of the weak force," said Fermilab physicist Ulrich Heintz, leader of the DZero *W* mass analysis, "the *W* has a fundamental place in the Standard Model. All of its properties are determined by the Model. Unlike the quark masses, for example, the *W* mass comes from the Standard Model. If we can't understand the *W* mass, we really can't say that we understand the Standard Model."

The Standard Model, the current theory describing the fundamental particles of matter and their interactions, was developed in the 1970s by Sheldon Glashow, Steven Weinberg and Abdus Salam. It unified the electromagnetic and weak interactions into one single interaction, called, naturally enough, the electroweak interaction. To make that unification, the Standard Model starts with a theory that has a fundamental symmetry such that all the carriers of the electroweak force (the photon, *W* and *Z*) are massless. (You can think of that fact as the symmetry.) However, this cannot be possible: the *W* and *Z* must be massive in order to account for the short range of the "weak" part of the interaction. In fact, because the range of the weak interaction, as its name indicates, is very small, the *W* and *Z* must have very large masses. The mass of the *W* is about 80 times the mass of the proton.



After *W*s are produced in particle collisions at the center of a detector, they decay very quickly. Consequently, they can be identified only through their decay products. In the decay used at Fermilab, the *W* decays to a lepton (an electron or muon) and its antineutrino. The antineutrinos and neutrinos pose a challenge to detectors: they interact very little and thus escape undetected. Their presence is inferred by an imbalance of energy in the detector, the so-called "missing energy." In this beam view of a $W \rightarrow e + \nu$ decay in the DZero detector, the circular histogram shows the energy detected in the calorimeter in the direction perpendicular to the beam. The spike at the top represents the electron's energy; the one at the bottom indicates the missing energy. The mass of the *W* is reconstructed from the energy of the electron and the missing energy.

Therefore the Standard Model's fundamental symmetry of massless bosons must be broken. Understanding exactly how it is broken is perhaps the central challenge we face in particle physics. The Standard Model accounts for this broken symmetry through the so-called Higgs mechanism, a phenomenon that leads to the prediction of the existence of a new particle, the Higgs boson, that no one has yet observed.

The Higgs boson is the missing piece of the so-far very successful Standard Model. The search for the Higgs is clearly a major goal of all current and future colliders, including Fermilab's Tevatron, CERN's LEP and LHC, and other machines still on the drawing boards.

The Standard Model also predicts a relationship among the masses of the *W*, the top quark, and the Higgs boson. Precise measurements of the mass of the *W* and top will indirectly constrain, or pin down, the mass of the Higgs. Pinning down the Higgs mass is very important, because it will tell us in what mass range we should look for the Higgs in direct measurements, somewhat as it happened for the *W* and *Z* (see caption). Later, if and when the Higgs is discovered, the comparison of direct and indirect measurements will provide a strong test of the Standard Model.

Fermilab, with the highest-energy hadron collider in the world, the Tevatron, and its detectors, DZero and CDF, is currently leading the way not only in direct measurement of the mass of the top quark, but also of the *W* boson, with a current preliminary combined uncertainty of about 90 MeV/c^2.

DZero's Heintz says the collaboration has now reconstructed about 70,000 *W* events in the electron decay channel for a mass measurement of 80.440 ± .110 GeV/c^2. CDF's Young-Kee Kim, that collaboration's *W* convenor, cites a figure of 90,000 reconstructed *W* events for CDF's value of 80.375 ± .120 GeV/c^2. However, the CDF mass measurement does not yet include all the latest data from Run Ib at the Tevatron.

"CDF will not have its final *W* mass from Run Ib until next summer," Kim said. "There are still things about the data we need to understand. We suspect we need to understand our detector's tracking system better. Much work is currently going on at CDF to do that."

Heintz concurred that the very high precision of *W* mass measurements requires excellent detectors and a very good understanding of detector properties.

"Measuring the *W* mass is different from the other particles we study," Heintz said, "because the precision is greater than for any other measurement. To measure the *W* mass,

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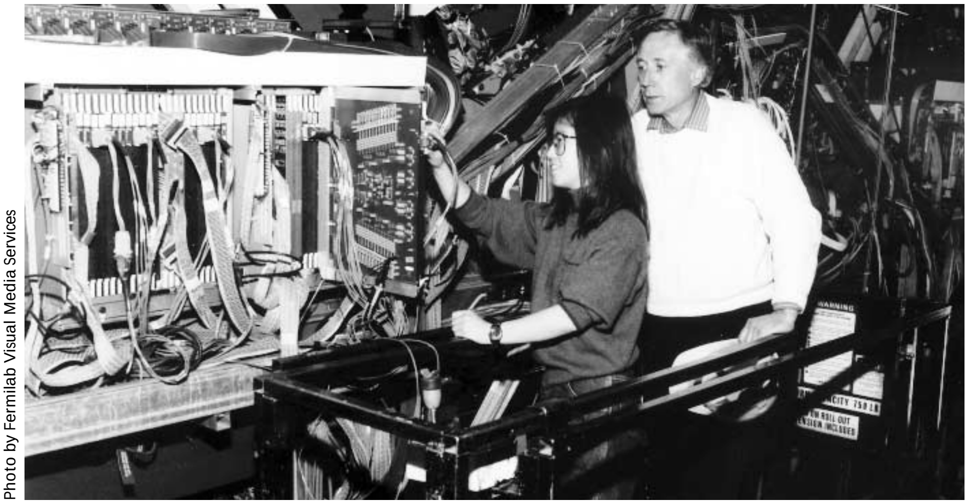
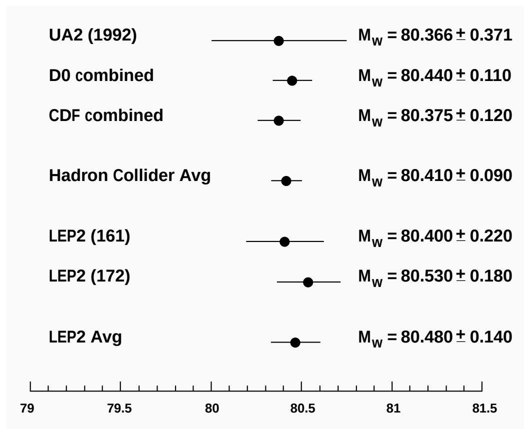
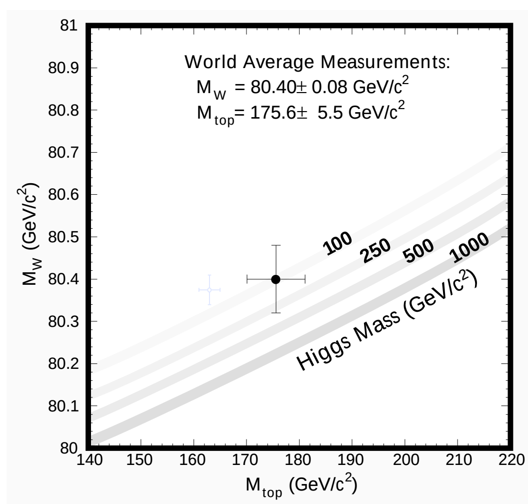
Photo by Fermilab Visual Media Services



The convenor of CDF's *W* group, Young-Kee Kim of the University of California at Berkeley, is shown here as a Berkeley postdoc in 1992. She and CDF cospokesman Bill Carithers work on their detector in preparation for Run I, which began in 1992. Besides discovering the top quark, Run I produced the world's most precise direct measurement of the *W* boson.



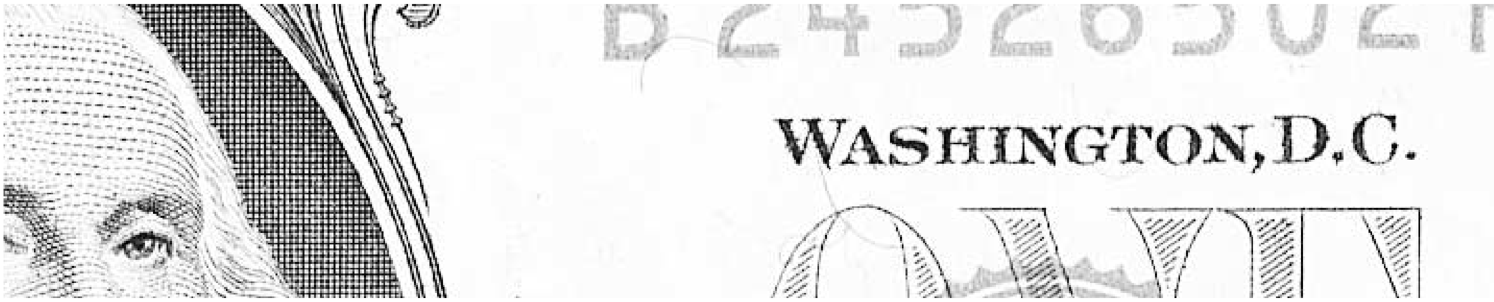
Best current direct measurements of the *W* boson mass (in GeV/c^2) from experiments at CERN and Fermilab. For LEP, the numbers in parentheses indicate the accelerator's energy.



The Standard Model relates the masses of the top quark and the *W* boson to the mass of the still-undiscovered Higgs boson. The large data point shows the current world average value for the *W* mass versus the world average value for the top mass. The bands correspond to different values for the mass of the Higgs boson. The small data point indicates the projected uncertainty on the top and W masses for combined CDF and DZero results at the end of Tevatron Run II.

Photo by Bob Palmer

The Standard Model predicted very precisely the mass of the *W* and *Z*. In 1983, in a stunning confirmation of the Standard Model, the *W* and *Z* bosons were discovered at CERN at exactly the mass where they were expected. Their discovery led the following year to a Nobel Prize in physics for CERN physicists Simon Van der Meer (above) and Carlo Rubbia.



While its hallways seem far removed from the world of accelerators and experiments, the Washington home of the Department of Energy's Office of High Energy and Nuclear Physics is at the center of forefront physics research in the United States.

by Judy Jackson, Office of Public Affairs

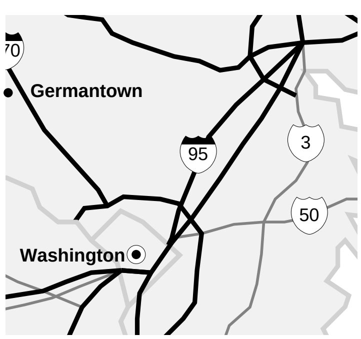
Photo by Bob Palmer

Associate Director Peter Rosen heads DOE's Office of High Energy and Nuclear Physics.

Willie Sutton said it: "It's where they keep the money." Actually, unlike the targets of the late notorious bank robber, they don't exactly keep the money at the Washington home of the Department of Energy's Office of High Energy and Nuclear Physics, which isn't exactly in Washington, either. But the people in the HENP Program Office in suburban Germantown, Maryland, do plan for, fight for, budget and distribute nearly all of the billion-plus dollars that Congress appropriates for U.S. high-energy and nuclear physics research each year. Which is why, in the words of John O'Fallon, director of DOE's High Energy Physics Program, "It all swirls around here."

The Department of Energy funds more than 90 percent of federally supported research in high energy and nuclear physics. (The National Science Foundation funds the rest.) The FY1998 budget enacted by Congress allocates $678 million for research in high-energy physics and $321 million for nuclear physics research.

"Our job is stewardship, to nurture physics research, to make it healthy and well and growing," O'Fallon told a recent visitor to Germantown. "What do we do? We fight the budget wars to get money, in cooperation with the physics community. We put together a budget for the coming year. We present it in this office and up through [Office of Energy Research Director] Martha Krebs. Our task is getting the money to do the research, so we can give it out."



Like ancient Gaul, DOE is divided into three parts: Forrestal, Germantown, and regional operations, or "field," offices. Peter Rosen, associate DOE director for High Energy and Nuclear Physics, explained the relationship between two of the parts: headquarters, located in the Forrestal Building in downtown Washington opposite the Capitol Mall, and the program offices, located among the rolling strip malls of Germantown.

"Forrestal carries out administration and politics, and tries to raise money," Rosen said. "Out here are almost all the programs—not just high-energy physics, but almost all the operations. Here in Germantown, the work we do is very closely related to the field itself, to the programmatic part of DOE.

"The more I learn about my role," said Rosen, a theoretical physicist who joined DOE in 1996, "the more I see it as a bridge between the two. I carry the program needs to Forrestal, and I bring back here to Germantown the fiscal reality. I make clear what restrictions apply—for example, the funding cap for the Large Hadron Collider. We have to be strict constructionists when it comes to LHC funding. We have to live within the limit Congress has given us, much as we might like to add to it."

In FY1998, Congress appropriated $35 million of a total of $450 million in DOE funding (and $81 million for NSF) to allow U.S. scientists to collaborate in the design and building of the Large Hadron Collider and its detectors to be built at CERN, the European Particle Physics Laboratory in Geneva, Switzerland. The U.S. funding will stretch over eight years and is strictly limited to the total specified by Congress.

Collaborative agreements like the one with CERN, which allow international cooperation among the world's physicists, also fall within the responsibilities of the Germantown program office, where the concept of international collaboration received strong support from several quarters.

"To build bigger machines in the future—unless there is some unexpected technological breakthrough—will require international cooperation," O'Fallon said. "I hope that the U.S. will come to realize that. There will be many challenges as we move toward more international collaboration. For example, how will we manage an international laboratory? Then there's the money issue—where the money comes from and where it goes.

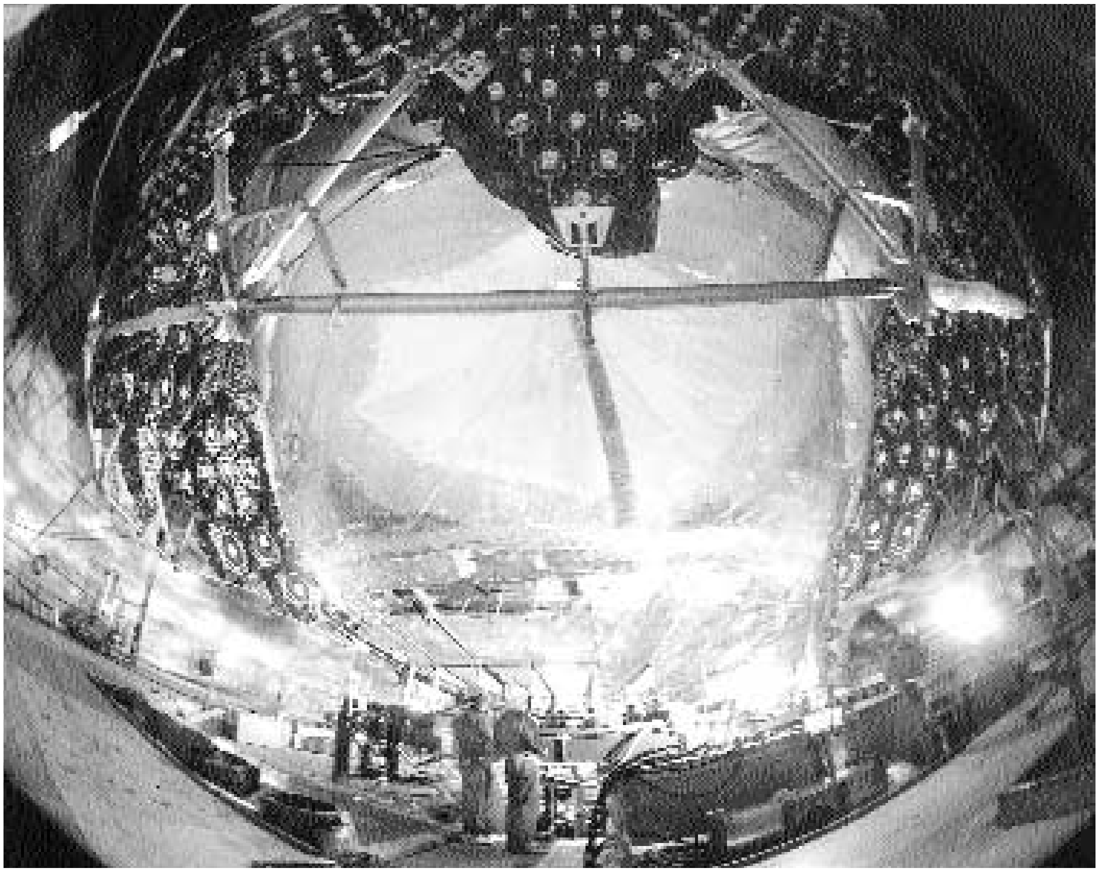


Photo courtesy of Lawrence Berkeley National Laboratory

The detector for the Sudbury Neutrino Observatory being built in Ontario, Canada, to determine if neutrinos from the sun are transforming from one kind to another. The SNO Project is part of the Nuclear Physics Program.

However, I believe the field of high-energy physics understands that internationalization is the direction it must take."

Rosen stressed that his vision for the future of the field of high-energy physics develops not in the isolation of his Germantown office but in continuous dialogue with the U.S. physics community, including the members of HEPAP, the High Energy Physics Advisory Panel, and its subpanels.

"I suppose I could try to be dictatorial, although that is not in my nature," Rosen said, "but I don't think that would serve the field very well. However, I do think that for high-energy physics to progress, we must go forward on an international basis. We must find a global equivalent of HEPAP that is reasonably representative of the field across all regions. I see it as my role to help us move the U.S. program in that direction."

Besides funding for construction and operation of high-energy and nuclear physics laboratories such as Fermilab, the Stanford Linear Accelerator Center, Brookhaven National Laboratory and Thomas Jefferson Laboratory, HENP also provides funds for experimental and theoretical physics groups at over 100 U.S. universities—for many of the "users" who come to collaborate on experiments at Fermilab, for example. P.K. Williams heads the university program within the Division of High-Energy Physics.

"The university programs have been hard pressed recently," Williams said. "The goal is to maximize the science within the prevailing budget situation."

Each university grant has a grant monitor from the Office of High Energy and Nuclear Physics. In his grant-monitor capacity, Williams said he visits 25 or 30 universities each year, trips that, he says, are fascinating but can also be somewhat discouraging.

"So often we have to say, 'You have a great program here. Keep doing it with three percent less funding next year.' There are exceptions, but not many."

However, Williams says, "There's one good thing that has come out of our troubles. University scientists are learning to be very effective in communicating with legislators. They write letters and help organize outreach efforts. They are learning to become much more effective communicators."

The importance of improving communication is an oft-echoed theme along the cream-colored halls of Wing 4-G, the home of High Energy and Nuclear Physics in the maze-like four-story brick Germantown building.

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A visitor needs a map to find the way through the labyrinth of DOE's Germantown building.

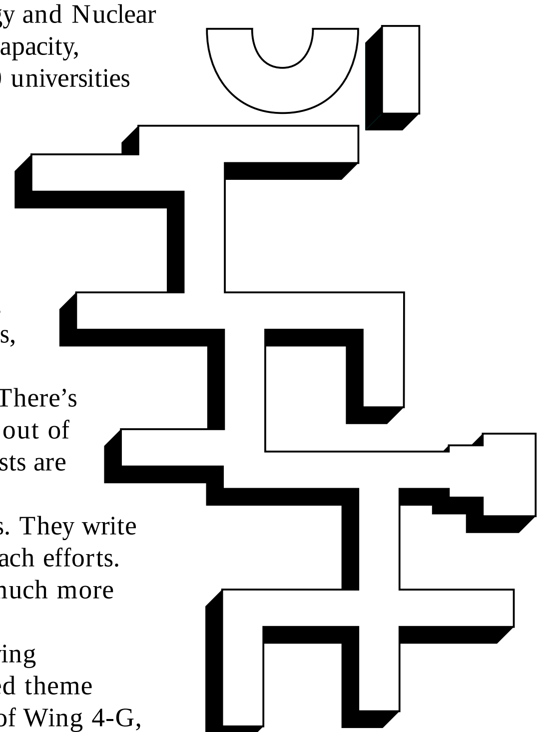


Photo by Fermilab Visual Media Services

Photo by Reidar Hahn

Construction of the Main Ring, with the first magnet set in place, in April 1970. Inset: Fermilab's spanking new 8-GeV beamline.

WBS: For Big Projects, the Indispensable Tool

by Sharon Butler, Office of Public Affairs

When God created the world, Peter Limon, head of the Technical Division, insists, He must have had a WBS—a work breakdown structure.

How else could He have accomplished such a monumental task?

After all, no major Fermilab project has ever proceeded without one. Even founding director Bob Wilson, a maverick in accelerator construction, had a WBS—although it went by another name.

Definitions

In the turgid jargon of management instruction books, the WBS is a "product-oriented hierarchical breakdown of the work scope embodied in a numbering structure organized in a logical manner."

More colloquially, the WBS is a chart detailing all the work that needs to be done to complete a project—to build a detector, for example, or an accelerator.

It starts at the top with the largest systems and breaks those down into their component parts in a treelike structure. The WBS for the Main Injector, for example, divides the project into technical components, civil construction, and project management. These are broken down again. Under technical components, for example, are magnets, vacuum systems, and power supplies—10 categories in all. Each of these items is further subdivided. According to Steve Holmes, project manager for the Main Injector, the WBS ends up detailing 250 to 300 components.

Devising a WBS is a laborious project in itself, but it is a necessary tool for tackling the construction of the big-ticket items critical to the future of Fermilab—and to the future of particle physics.

Virtues of a WBS

The WBS has certain undeniable virtues. For one, it establishes the framework for the project's organizational structure. The work is laid out so that responsibility—or blame, jokes Limon—can be assigned. One person is in charge of magnets, another the power supplies.

Moreover, using the WBS, the project manager can estimate the overall budget. Costs

The WBS … is a necessary tool for tackling the construction of big-ticket items critical to the future of Fermilab—and to the future of particle physics.

are calculated for the lowest-level components in the WBS (the 250 to 300 parts for the Main Injector, for example) and for the labor required to produce them. The costs are then "rolled up" to get dollar figures for the major components of the project, as well as the grand total.

The project manager can also use the WBS to track the financial status of the project. Since each item has a unique number and the accounting system at Fermilab is tagged to these numbers, the project manager can assess whether the project is overspending for certain components or whether it is underspending, and hence behind schedule.

Even scheduling can be integrated into the WBS, whether the time frame is seven days, as in the world's creation, or seven years, as in the Main Injector's. Scheduling gets tricky, since the construction and installation of one component often depends on the delivery of other components—e.g., cooling pipes can't be connected until a magnet is installed. A full-blown integrated resource-loaded schedule will detail the level of manpower and money needed at each step along the way.

While much of the WBS seems intuitive, even obvious, misapplications can lead to problems. For example, according to Holmes, by assigning installation a separate category, alongside magnets and power supplies, and placing a mechanical engineer in charge of the installation work, inefficiencies and even confusion resulted for the Main Injector project. The mechanical engineer knew all about installing magnets, but his assignment involved installing such things as control cards as well. The person in charge of control cards therefore did the planning for that work, but the mechanical engineer still needed to oversee the budget and sign purchase requisitions. Every time he had to sign a requisition for installation equipment for control cards, he had to consult with the control cards manager to determine whether the purchase was necessary. Holmes later modified the WBS to smooth out the organizational snag.

Silly or necessary?

Depending on the size of the project, of course, a WBS can be silly or necessary, according to physicist Gerry Jackson. For smaller projects, a WBS may be more trouble than it is worth. But for the $230 million Main Injector, Holmes insisted, the WBS was essential.

With 250 to 300 "little projects" to manage, he said, "keeping track of these projects, knowing which should be going when, and knowing how much money we should give to which manager to do what work—especially under the less-than-optimal funding profiles we have—would be totally impossible without some sort of formal structure like the WBS."

Even Jackson, in charge of the smaller $12.5-million Recycler project, is now one of the converted. Generally skeptical of any bureaucratic imposition, Jackson never before saw the need for a system to "track performance." He always figured it was "better to trust people than to ask for their signatures."

For the conceptual design report, Jackson says, he was able to have "some global control." But once the project started rolling, he learned that "things very quickly accelerated." Questions popped up (e.g., how many technicians to assign to which task), glitches caused temporary setbacks, the unexpected occurred. For Jackson, the WBS served as a means of easy access to information and a quick reference to the managers responsible for each task.

Of course, the U.S. Department of Energy and Fermilab's director and deputy director all expect the managers of large construction projects to produce a WBS. But even if they didn't, Holmes said, "we would do it anyway—it's the only way to organize the work effectively." ■

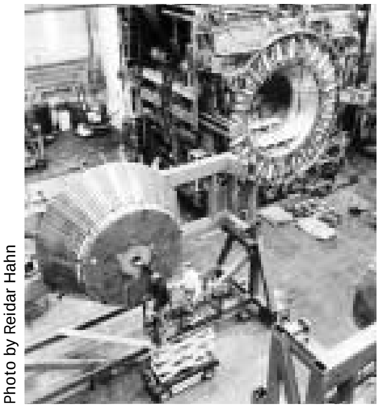


Photo by Reidar Hahn

New end plug for the CDF detector, part of the upgrades for Run II.

Photo by Reidar Hahn

Civil construction at FZero, making way for the Main Injector.

Winter Drops in at Fermilab

Photo by Fred Ullrich

The Neutrino barn

The Big Woods

The Meson Lab

Photos by Jenny Mullins

Lake effects

Work in Progress

With only months to go for completion, the Main Injector underwent its latest Lehmann Review in mid-November.

by Judy Jackson, Office of Public Affairs

Photos by Reidar Hahn

The Fermilab Main Injector Project as it appeared from the air on October 29, 1997.

"What is it, number fourteen, right Phil?" the Department of Energy's Danny Lehmann asked DOE physicist Philip Debenham, the organizer of the latest in a long series of project reviews for Fermilab's $229-million Main Injector Project. The panel of DOE reviewers and expert consultants assembled on November 18–20 to assess the health and progress of the project as it nears its final stages.

Fermilab Director John Peoples Jr. welcomed the review committee to the Lab, leading off on a distinctly somber note.

"I have great concerns about the turn-on of the Tevatron in 1999," Peoples said. "We will need an additional six to seven million dollars to operate for three months in 1999, for cooldown, commissioning and limited fixed-target physics."

Peoples said that although it would make sense to operate more than one fixed-target experiment at the Tevatron in the months before collider physics can resume, reduced funding levels contemplated for FY1999 will permit operation of at most one experiment. He presented a draft long-range schedule for Tevatron operation that allowed a six-month fixed-target run between April 1999 and February 2000.

Peoples added later that there is renewed interest in the Administration in making use of the new construction projects such as the Main Injector and the SLAC B-Factory.

"If that interest materializes in an appropriation that compensates for inflation and aging infrastructure projects such as Wilson Hall," he said, "then there will be a superb fixed-target run. But without more funds, we may have to delay Tevatron commissioning until FY2000, rather than beginning it in FY1999."

The review committee then went on to examine all aspects of the Main Injector project, including the recently added Recycler Ring, the status of all the project's subsystems, safety issues, and the Laboratory's plans for completing and commissioning the new accelerator.

At the review's conclusion, both Debenham and Lehmann expressed optimism about the satisfactory completion of the project, tempered with concern for the amount of work still left to finish and the importance of success.

"It was a very important review," Debenham said, "because it is crunch time for the project. It is an intense and important time for the Main Injector."

Debenham said the committee had concerns in several areas but believed "it can be done" nevertheless.

"As we have become accustomed with this project," Debenham said, "there has been good progress, especially with the Main Injector itself. The Recycler, a new project now only six months old, is still not up to speed. The review committee believes that with great management, Fermilab can do it. The professional approach and management structures that have been so successfully applied to the rest of the project now need to be applied to the Recycler."

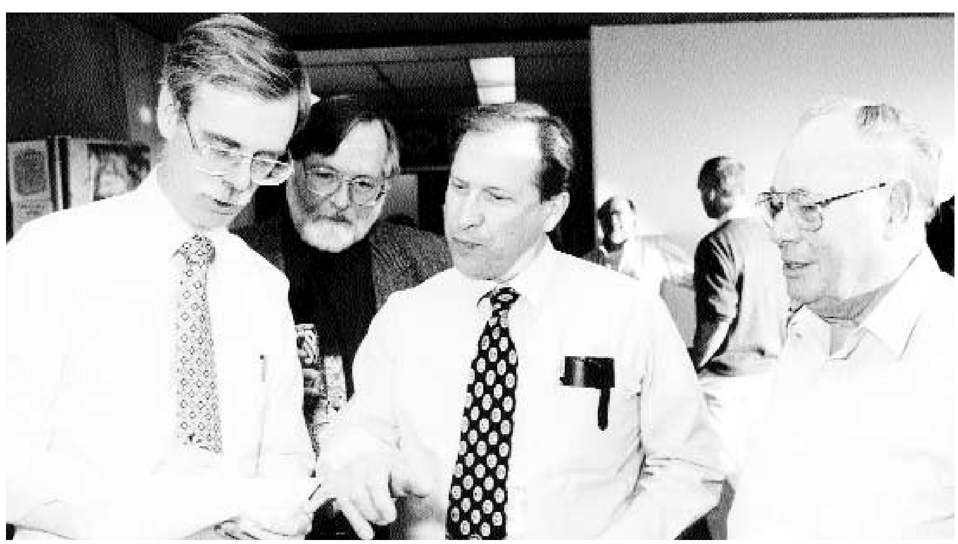
Lehmann agreed.

"The committee feels that the Main Injector team has done a good job to date, and they have a lot more to do to achieve a Level Zero decision for having the facility ready to operate by March 1999."

A Level Zero decision is the final high-level DOE decision that will allow the Main Injector to begin operating.

Debenham said he knows it is not necessary to motivate Fermilab to give the Laboratory's best efforts to completing the project.

"You know how important the Main Injector is to the physics of the next 10 years. Right now, DOE and contractor credibility is being challenged in the area of project management. We have to show that we can carry out projects safely, on time and on budget. Finishing the Main Injector will help us answer these challenges. It is important to succeed so that we can point to actions, not words." ■



Left to right: Main Injector Project Manager Steve Holmes and Beams Division physicist Phil Martin discuss the project with DOE reviewer Danny Lehmann and Paul Reardon, one of the review committee's expert consultants.

Water Woes at Main Injector

by Judy Jackson, Office of Public Affairs

Water standing in the low-conductivity-water cooling system for Fermilab's new Main Injector accelerator proved a spawning ground for metal-eating bacteria that attacked the system's pipes. The bacteria, which have not yet been definitively identified, produced acid by-products that ate through the stainless-steel pipes of the water system at the welds between sections, causing more than 200 leaks and more than a little consternation to the project's managers.

Main Injector workers discovered the first of the leaks late in November and quickly moved to understand and control the damage.

"Our strategy is first to contain the problem," said Project Manager Steve Holmes. "We want to make sure that no more damage occurs. Then we will assess the damage and fix it, as quickly and as economically as possible."

Workers had filled the first section of water pipes with well water in the spring of 1997. Hydrostatic tests at the time showed minimal leaking. Workers then closed off the first tested section, leaving the water in the pipes. They then filled and tested the next section, and so on, finishing the fourth of six sections in mid-October 1997. As a result, water stood in some of the earliest-tested pipes for as long as six months.

Since detecting the leaks, Fermilab project managers working with outside experts have determined that, over time, bacteria in the water attacked at the points where welds altered the metallurgy and structure of the pipes, forming "pockets" of acid that corroded the metal. So far, the leaks appear to be confined to the area of the welds.

As soon as they had identified bacteria as the cause of the leaks, staff took the first steps in damage control, the introduction of a biocide to kill the bacteria. Tests are now in progress to determine the kinds of bacteria present (there may be more than one), the efficacy of the biocide, and the exact extent and nature of the damage.

Why did the leaks occur? Fermilab has many other stainless-steel water systems that have never developed leaks. The difference, said Associate Project Manager Phil Martin, is that in those systems the water was moving, preventing the bacteria from growing and attaching to surfaces.

"It is stagnant water that causes this problem," Martin said. "We have since learned that this type of damage costs billions of dollars a year, yet knowledge on the subject is not widely documented. Nevertheless, we should have known about it. Had we known, we could have prevented this from happening at minimal cost."

At first, project managers thought the leaks might be so widespread that the entire $6-million system might have to be replaced. Further investigation, however, suggests that cutting out the leaky welds and welding in new sections may solve the problem at a far lower cost, project officials said. They have already begun discussions with contractors to carry out this work.

"We will drain a sector of the system, make the repairs, clean and treat it, then drain the next section and repair that," Martin explained. He noted that the repair work must be planned so that it does not interfere with the complex choreography of other installation tasks that must continue in order to finish the Main Injector.

"We want to get the water circulating in that system as quickly as possible," Martin added. "And when we do, we'll keep it circulating." ■

Photo by John Satti

The dark liquid in the bottom of the pipe shows the build-up of acid-generating bacteria in a stainless-steel pipe of the water cooling system of Fermilab's Main Injector project.

Marks indicate the location of a leak in the weld of the low-conductivity-water system. Most of the leaks, caused by corrosion from acid produced by bacterial action in water standing in the pipes, appear to be confined to the welds.

Photo by Fred Ullrich

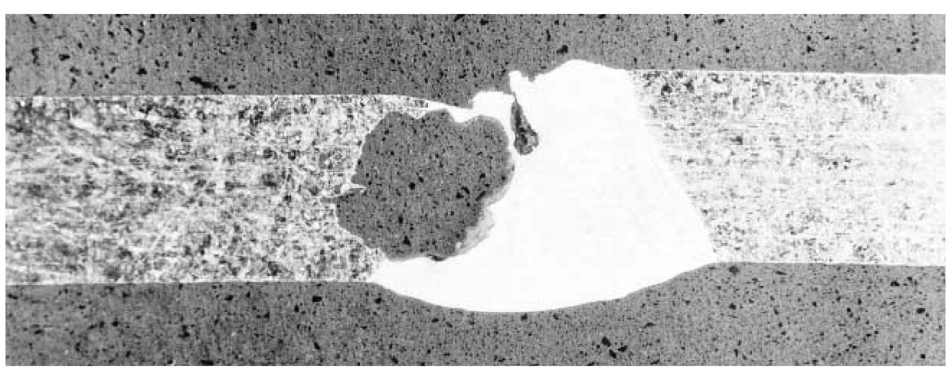


Photo by John Satti

An enlarged cross-section of the wall of a stainless-steel Main Injector pipe shows a pocket of bacterially-induced corrosion at the weld.

Profiles IN PARTICLE PHYSICS

Herman White

Physicist

ID #2568

by Sharon Butler, Office of Public Affairs

Walking up 13 flights in the Wilson Hall high-rise, a daily regimen, physicist Herman White arrives at his cubicle panting. When he catches his breath, he settles down among tidy piles of paper to contemplate, among other things, the development of a superconducting radiofrequency-separated beam of kaon particles. No one has attempted such a beamline since CERN, the European Laboratory for Particle Physics, built one in 1977. It's a difficult task, but at Fermilab, White affirms, difficulty deters no one.

In fact, White says, Fermilab's job is to solve the difficult, and that's why he's here. "If you want to do mundane things, you should probably go work at Sears."

White's been at Fermilab now 23 years, and takes quiet satisfaction in having created with his colleagues things that lasted: the detectors built in the 1980s that still serve the frontiers of particle physics; the summer physics lecture series for undergraduate and graduate students that still packs the conference halls.

Looking back, White maintains that hard work and luck got him where he is today.

"Luck—now that's an important word," he says. The word recurs several times over in a hour's conversation about a personal and professional journey he says he could never have predicted.

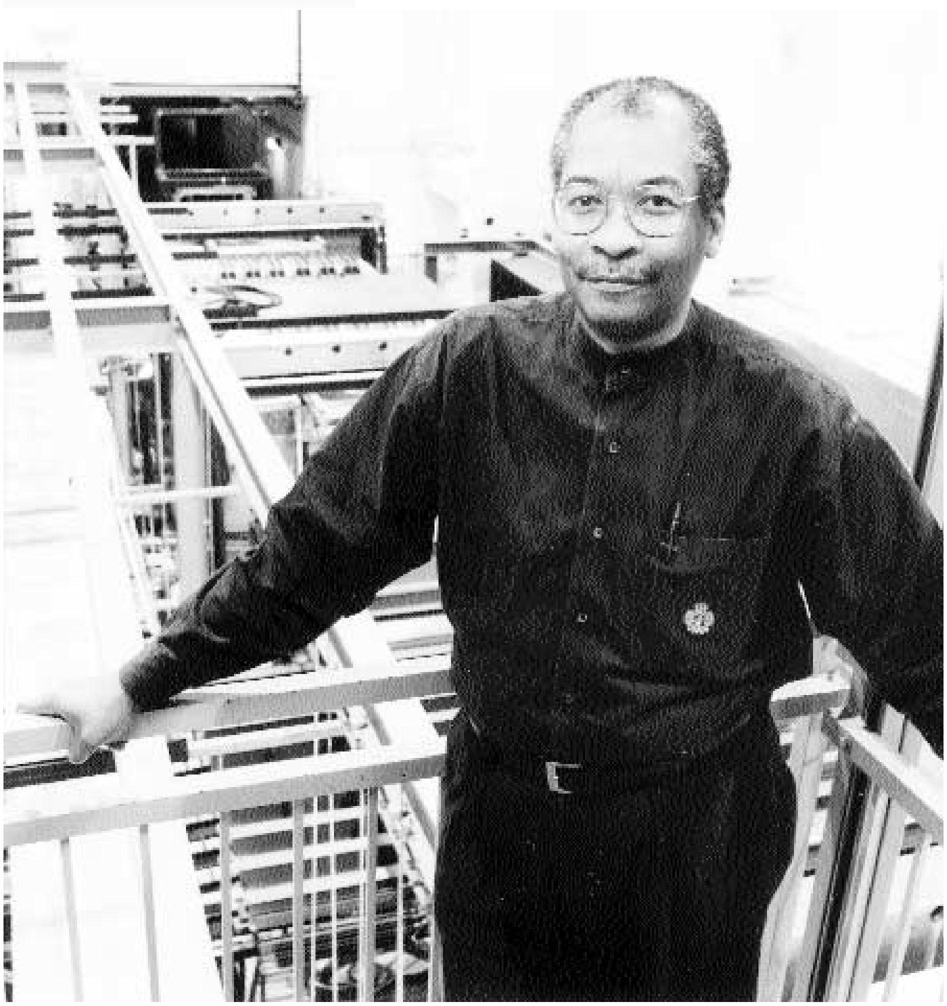


Photo by Reidar Hahn

White grew up in Tuskegee, Alabama, in the 1950s. Home of the famous Tuskegee University, founded by the eminent black scholar Booker T. Washington, Tuskegee was "an academic community in a segregated society," White says. The majority black population included doctors and lawyers, as well as farmers and sharecroppers, but the public library was closed to black people. Racial tension surged all around him, but it "was just part of growing up," White says with typical understatement. Political troubles never impinged on his choice of career. At Earlham College, an intense liberal-arts college in Indiana, he buried himself in physics texts even when protests were erupting over the bombing of Cambodia.

Luck, White says, brought him to Fermilab at just the right time—in the early 1970s, when the Laboratory was more start-up than going concern. In those days, he says, many experimenters were proposing "taking a proton beam, hitting a stationary target and then looking for whatever came out of the collision." With more flexibility then in programming and funding, White remembers with relish, physicists were eagerly proposing new ideas. Nearly every experiment was a first. At very high energies, he explains, particle physics was "not yet so well-defined that experiments all had to test the Standard Model."

"We were lucky to be here," says White.

An occasional spokesman for the Lab and for particle physics—at Kiwanis clubs and on National Public Radio—White advances a convincing argument that science merits the country's investment. Making that argument is tricky, he says, because our MBAs demand "results by the third quarter." Subjects like the violation of charge, parity and time may lead to new inventions, "but long, long after I am dead," White concedes. "Our job is to advance knowledge and erase ignorance."

Still, as he said to one man at a public talk who complained about the millions invested in high-energy physics, think about the World Wide Web, generating millions of dollars in business each year. The Web, he asserts, "is just one idea that came out of, not just the science community, but the high-energy physics community."

"With even a tiny percentage of the revenues from Web business," White declares, "particle physics could survive for decades."

And with hard work and luck, it might even flourish. ■

W Boson

continued from page 3

we must probe the detector calibration at levels no other group does. We need a higher level of precision, starting from the ground up; so we wind up doing a lot of work on the detector to make sure that we get it."

The precise measurement of the *W* mass at hadron colliders has been a great achievement. It is often suggested that lepton colliders are cleaner because of the simpler initial state, and that therefore it is difficult, if not impossible, to make precise measurements at hadron colliders. Events have shown that this is not true for the *W* mass.

Experiments at CERN's LEP accelerator are currently producing pairs of *W* bosons.

"LEP has now increased its energy to a point where one can produce two *W*s," said CERN's Blondel. "Although the production rate is small, the excellent performance of LEP in 1997 has allowed production and reconstruction of about 1,000 *W* pairs in each of the four LEP experiments. That makes 8,000 *W*s in all modes." The current combined LEP result is 80.480 ± .140.

Future measurements

Fermilab's Run II at the Tevatron, the first collider run of the Main Injector era, scheduled to start in 2000, will accumulate 20 times more *W* events. The CDF and DZero detectors are being upgraded for higher performance.

Heintz says that in Run II, DZero expects to achieve a precision of 40 MeV/c^2 in the electron decay channel, and Kim looks for a similar precision at CDF, although "until we open the bottle, we won't really know," she said.

Experimenters at LEP expect to reach the same kind of uncertainty in direct measurement.

"The best *W* mass determination at the moment comes from the Tevatron, where *W*s can be produced singly," Blondel said. "By the end of LEP in the year 2000 and with the future Tevatron runs..., one should be able to pin down the Higgs boson mass with a relative precision of 20 percent."

There is also a proposed project at Fermilab to run beyond Run II, to increase the number of *W* events by another factor of 15, with the potential of reaching a *W* mass uncertainty of 15 MeV/c^2. Later, the LHC will also have the opportunity to do a very precise measurement.

Knowing where the Higgs might lie is also very important for the planning of the future of the field of particle physics, as it may help pin down the right machine to build beyond the LHC.

Just now, however, Fermilab's energies are concentrated on finishing the Main Injector and upgrading the collider detectors for Run II in the year 2000. Then, says Heintz, "at Fermilab, we will measure *W* and top to close the loop on the Higgs boson." ■

Photo by Reidar Hahn

Wires and cables for the detector at Fermilab's NuTev experiment transmitted data that will help pin down the *W* boson's mass. Physicists Lucy de Barbaro, of Northwestern University, and Howard Budd, of the University of Rochester, check the connections.

W Measurements—A Winter's Work

By Bob Bernstein, Fermilab physicist and NuTeV cospokesman

What are some other methods of measuring the *W* mass? Why are they important? We can answer these questions by realizing that the Standard Model relates the masses of the *W* and *Z* bosons to how strongly they interact with quarks.

"**W**eak interactions" describe the way quarks and leptons interact. Whenever a lepton, such as a neutrino (as in the Fermilab experiment called NuTeV) interacts with a quark, the lepton emits a *W* or *Z* boson. (Wiggly lines in Feynman diagrams represent *W*s, *Z*s, photons or gluons.) Weinberg, Glashow, and Salam devised a theory describing this process, which grew into what we now call the Standard Model. Within the rules of Feynman diagrams we find we must weight the strength of the lepton-quark interaction by $\sin^2 \theta_W$. ("*W*" stands for "Weinberg" if you're not from Harvard {where Glashow is} and "weak" when you're being polite.)

We get the payoff by noting the following relationship: $\sin^2 \theta_W = 1 - (\text{W Mass} / \text{Z Mass})^2$. With this equation we can link the *W* mass measured at the colliders to the weak mixing angle measured in neutrino scattering experiments. When neutrinos were the only game in town, they provided the most accurate measurement of the *W* mass; with the advent of UA1 and 2 at CERN, and CDF and DZero at Fermilab, the colliders took the lead.

Widespread opinion held that neutrinos would be henceforth useless for precision *W* mass measurements—until NuTeV collaborators took data and proved other scientists wrong. Weathering withering words of criticism, the neutrino experimenters worked through a weary winter, harvesting a wealth of data: we now have roughly equal precision in the neutrino and collider measurements, about one part in 800 of the *W* mass. ■

Washington

continued from page 5

Photo by Reidar Hahn

Dr. John O'Fallon, director of DOE's High Energy Physics Program, is a familiar figure at Fermilab reviews. At O'Fallon's left is Pat Rapp, DOE's program officer for Fermilab.

Concern for communication starts at the top, with Associate Director Rosen.

"We need to do a better job of building support with our fellow scientists and with the public," says Rosen. "I hope to help set things in motion, activities and policies, to do that. Building support is a vital activity, with lots of give and take."

Rosen admires and hopes to emulate the National Air and Space Administration's "prescient" policy for public relations, "integrating it into every activity, rather than merely trying to add it on at the end."

David Hendrie, director of the Division of Nuclear Physics, agreed.

"Scientists need to connect," Hendrie said. "We need to get scientists more society-oriented. The community has changed as a result of the end of the Cold War. Nuclear physics is trying hard to make the case for basic research to the public."

Among the efforts the nuclear physics community has supported, Hendrie cited the production of several publications and wide distribution of a colorful new wall chart aimed at explaining nuclear science to nonphysicists and students.

Communication also surfaced as an important part of the answer to a question of considerable interest to a visitor from Fermilab: How does the Office of High Energy and Nuclear Physics make budget decisions?

"We have many discussions inside the office, with constant advice from the community," O'Fallon said. "HEPAP plays a very big role, although some may think it doesn't. The decisions we make affect very directly how the program goes. We get a lot of advice. At every stage, the community is always involved. The peer review system also kicks in, through organizations like the Fermilab Program Advisory Committee. And we review, review, review. People grumble about reviews, but I believe they understand how critical they are for the field."

Aerial view of Thomas Jefferson Laboratory in Newport News, Virginia, a key facility of DOE's Nuclear Physics Program. The nuclear physics laboratory's electron beam traverses the one-mile accelerator to probe the inner structure of the nucleon.

Photo courtesy of Thomas Jefferson Laboratory

O'Fallon pointed out the "considerable inertia" that exists in the annual physics research budget. "There is not a lot of annual fluctuation," he said. "There is a great amount of presentation required for the rationale for any new program or facility. There is much discussion within the office and within the community. Eventually, a consensus begins to grow about what should be done. Maybe we're in the middle of this process now with regard to the [International Linear Collider]. We're listening very carefully. At some point it will become clear that the ILC has or doesn't have community support. HEPAP is one important source of advice, but there are others."

Rosen underlined the importance of communication in making budget decisions: "The vision that I develop for high-energy and nuclear physics comes from talking with many, many people. We have to make choices because of resource restrictions. We have to exercise judgment. Ideas get jostled around, but eventually a vision starts to crystallize—one that I'm prepared to take ownership of and responsibility for. I get opinions from all areas of the field, but in the end, I have to make the decisions."

Laboratory monitors or program officers, including Pat Rapp, Fermilab's program officer, and Gordon Charlton, program officer for SLAC, also play a role in the continuous dialogue that suffuses the budget process.

"My role is to know the lab, the program, the budget and the user community in order to understand the impact of proposed actions," Charlton said.

Program officers also organize annual program reviews at each laboratory and assemble the panels of expert reviewers who examine the laboratories' scientific programs.

David Sutter heads the High Energy Physics Division program that funds the advanced technology research and development in accelerators and detectors that underlies the continuing advance of forefront research in particle physics. Sutter cited a figure of $67.4 million for "technology R&D" from a total FY1997 high-energy physics budget of $670.1 million. In a presentation of accomplishments and challenges of the R&D program, Sutter highlighted the technology for a possible future muon collider and the development of high-temperature superconductor as two areas of particular challenge and high possible payoff.

HENP office officials point with pride to the low ratio of their administrative staff to research dollars. The office's 40-odd employees give it the best ratio in DOE's Office of Energy Research of dollars administered per technical staff member.

In fact, the ratio is a little too good. The Office of High Energy and Nuclear Physics office is looking for a few good men and women. Especially women. Like the field as a whole, HENP lacks women in its technical positions and would welcome more. It is, says O'Fallon, an exciting place to work.

"You are really plugged into physics in this office," he said. "There is no better view of the world of physics than the view from here." ■

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 December 17

Saffron and Shrimp Risotto

Spinach and Pomegranate Salad with Champagne Vinaigrette

Chocolate Cherry Layer Cake

Dinner Thursday December 18

Chestnut Soup with Cognac Cream

Medallions of Lobster with Champagne Sauce

Vegetable of the Season

Christmas Salad

Chocolate Cup Raspberry Mousse

Assortment of Christmas Cookies

Lunch Wednesday December 24

CLOSED

Dinner Thursday December 25

CLOSED
Happy Holidays

CALENDAR

DECEMBER 12

NALWO potluck dinner, 6:00 p.m. at the Village Barn with drinks and appetizers. Dinner starts at 6:30 sharp. Everyone is asked to bring either a main dish for 6-8 people or a dessert for 12. We provide soft drinks for everybody, pizza for the kids and wine for adults. A babysitter will be there, too. For further information, contact Angela Jostlein, 355-8279.

Fermilab International Film Society presents: *Night of the Hunter*, Dir: Charles Laughton, USA (1955). Admission $4, in Ramsey Auditorium, Wilson Hall at 8 p.m.

DECEMBER 14

Barn dance at the Village Barn from 7 to 10 p.m. Live music and calling will be provided by the Chicago Barn Dance Company. The dances are contras, squares, and circle dances. All dances are taught, and people of all ages and experience levels are 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 information, contact Lynn Garren, x2061, or Dave Harding, x2971.

DECEMBER 21

Special holiday barn dance & concert with The More the Merrier at the Village Barn from 2–5 p.m. Concert admission is $8. Children under 12 are free. For more information, contact Lynn Garren, x2061, or Dave Harding, x2971.

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.

LETTERS TO THE EDITOR

On this side of the pond we have an excellent word for “ de-construct” and especially for “de-install.” It is “dismantle.” I am sure the Founding Fathers must have taken it with them. Is it lost?

Yours sincerely (and in continued awe of your pioneering work),

Chris Rogers

(Journalist at BBC South West, UK, and a continually-fascinated reader of FermiNews)

■

The November 21, 1997, issue was very good, very informative. This was the first time in a long time that *FermiNews* held my interest from cover to cover.

Paula Cashin

HOLIDAY SHUTDOWN

With the winter holidays approaching, Fermilab will once again reduce activity to a minimum. The Laboratory will close for normal operations at the close of business on Tuesday, December 23, 1997, and will reopen for business on the morning of Monday, January 5, 1998.

Of the eight workdays affected, two are half-day holidays (Christmas Eve and New Year’s Eve) and two are full-day holidays (Christmas Day and New Year’s Day). Employees will be paid for these days as usual. Employees who have vacation balances must use vacation or the 1997 floating holiday to cover the other five days. Those who lack vacation time to cover the five shutdown days will be excused without pay. The only employees required—or allowed—to work for pay during the shutdown are those designated by division and section heads as necessary for essential functions.

Paychecks

Monthly employees who would normally receive their pay on Wednesday, December 31, will instead be paid on December 23. They should submit their timesheets by Friday, December 12. Weekly employees will receive their pay for the weeks ending December 14 and 21 on December 23. Weekly employees should turn in their timesheets for the weeks ending December 14 and December 21 on December 12. For the week ending December 28, timesheets need to be turned in on December 18. Weekly employees will receive their pay for the weeks ending December 21 and 28 on December 23. (Please note that this will result in weekly employees’ having up to 53 weeks of earnings on their W-2s.) The Payroll Office will close during the shutdown, and no Payroll personnel will be on call.

Other activities

Salaried employees may come to their offices—without pay—and perform light office work such as working at computer terminals. (Federal law prohibits weekly employees from performing volunteer work at the Laboratory.) Except in specifically authorized cases, shutdown policy precludes work on experiments or elsewhere that requires two or more people, a policy that applies to users as well as employees.

The Users Office, the Travel Office and the Recreation Office and facilities will close. The cafeteria will close, but vending machines will be serviced. The Housing Office will operate at weekend levels, to deal with emergencies only. The Credit Union will close, and there will be no mail deliveries.

The 15th floor of Wilson Hall will remain open to visitors, including any who might arrive from the North Pole. Heat will remain on. A small on-call Computing Division support staff will attempt to maintain basic services. If it snows, the roads will be plowed. The Fire Department and the Communications Center will maintain their regular service. Security will operate at weekend levels. Wilson Gate will be closed, but Pine Street and Batavia Road will remain open. ■

CLASSIFIEDS

FOR SALE

■ '94 Dodge Caravan Grand LE, 42K miles, luxury package, power everything, 3.8-liter V6, anti-lock brakes, dual airbags, quick-removal seats, 140 cu.ft. cargo area, tinted glass, much more. No damage history. Asking $14,999 obo. Call Vic, (630) 513–1000.

■ '88 Toyota Tercel DX, 5-door hatchback, very good condition, extremely reliable, 121K miles, auto, PS, A / C, cass, $2,300. Contact Yael, x4494 or yshadmi@fnal.gov.

■ '85 Golf diesel w / 5 speed. Gets about 45 mpg. Runs great & starts well in winter. Well maintained w / receipts. Solid car. 190K miles. Make offer. Contact (630) 243-1125.

■ Autofocus, Minolta 400SI w / AF35 / 70 lens w / filter, carrycase, direction video, camera bag, plus Sigma 70-300mm / macro lens w / filter. All purchased within the last 6 months, have receipts & original boxes. All for $700. Nikon user now. Contact Charlotte, x8640 or (630) 892–2887.

■ Bradford Exchange Collector Plates: v-Palekh Art Studios Russian Legends. The first 5 of the folklore series of limited-edition porcelain plates created in Russia. They are crafted in the age-old tradition of miniature paintings on lacquer. Russian & Ludmilla, $30. The Princess / Seven Bogatyrs, $30. The Golden Cockerel, $33. Lukomorya, $33. Fisherman & the Magic Fish, $33. Call Bob, x2634 or (630) 495–5820.

■ Sega Genesis video game system, 29 game cartridges. System includes console unit, two controllers, AC adapter & all required cables / manuals in original box. Game cartridges include Earthworm Jim, Ecco, Landstalker, The Immortal, Rolling Thunder II, Terminator, Where in the World is Carmen Sandiego, Star Control, Flashback, Alisia Dragoon, Arcus Odyssey, Shadow Run, Rings of Power, F22 Interceptor, and many more! Asking $40 for Genesis system, $80 for all 29 games, $100 for both system & all games. Please inquire for individual game pricing. Final Fantasy VII game for Sony Playstation (3 CDs, US original w / manuals, $35; Macintosh computer games: Secrets of Luxor Pyramid,$10; Amber Journeys Beyond, $15, Blackthorne, $10; Prince of Persia II, $8; Rebel Assault II, $12; Shadowraith, $10; Creep Night 3D Pinball, $15; Full Throttle, $15; and more. Please inquire for bargain pricing. Home lighting fixtures, brass finish, in excellent condition w / mounting hardware. Dining room five-bulb hanging chandelier, $30; matching kitchen wall four-bulb fixture, $25; foyer four-bulb ceiling fixture $20; pair of exterior wall mount porch lights,$30 for the pair. Take entire set for $90. Contact Pat, x2814 or hurh@fnal.gov.

■ Nordic Trak, Achiever model w / heart monitor & BC886 II computer. Like new w / instruction book. Cost $950; asking $450. Machine shop: Bridgeport mill, clausing lathe, Norman Miller mill & more. Call Vic for details, (630) 513–1000.

■ Paperback books, exc. cond., 24+ per box, $5 a box. Autobiography, novels, etc. (630) 896–3211.

■ Bessler 67cp enlarger with two lenses, $50. Misc. darkroom equipment, good start on basic darkroom, $25. Two windows, good condition. wood double-hung w / self-storing aluminum storms & screens, fit 42" W X 41 3 / 4" H opening. Free to good home. Contact John Urish, x3017, (630) 393–2138 (evenings) or urish@fnal.gov.

■ Oscar Meyer Wiener mobile pedal car. Age 7 or under. New! $135. Call Jim, x4841.

■ Wurlitzer organ, 1968 model, maple, full upper & lower keyboards, foot pedals, & bench. Excellent condition. Asking $500. Contact Tom, x3441.

■ Weslo CardioGlide exercise machine. Like new $50; KitchenAid dishwasher. portable model w / cutting board top. VGC, $75. Call Mark, x2253.

RENT

■ Rent w / option to buy. Summerlakes home. 3 BR, 1-1 / 2 BA, 2 stories with attached 1-car garage. LR, DR, kitchen, fireplace and more. For details, contact Henry, x4157, EHSCHRAM@FNAL.GOV or (630)665-2434

■ Apartment, 2 bedrooms, lower level, Aurora (NE), $450 / month + 1 mo security. Available 12 / 15 / 97. References required. Leave message, (630) 801–1775.

■ Apartment in Batavia's Historic Bellevue Place (333 S. Jefferson St., Batavia). Available Jan. 1 (can move in after Dec. 23). This is the actual apartment where Mary Todd Lincoln stayed in 1875. Features include: 2 bedrooms, 1.5 bathrooms, high ceilings, tall windows, large living room, dining room, modern kitchen with dishwasher, central air, beautiful grounds, locked large storage area in the basement, central location (a few blocks to the swimming Quarry, bike paths, library, etc.), less than a half hour bike ride to the highrise. The rent will be $950 / month. Call (630) 879-3785. For further information, contact Susan, (630) 761–1233, or Scott, menary@fnal.gov or x5407.

WANTED

■ Child care for 1-year-old boy. Twice a week, 4 hours (morning). Initial appointment for 6 months. English or Russian native language. Adults only, please. Contact Julia, x8366, (630) 859-3463 or yarba_j@fnal.gov.

■ Good home for two rescued kittens that I am bottle feeding. Long hair and REALLY cute! One all gray male and one tiger-striped female. Call Edie, x3621 or (815) 496–9434.

LAB NOTE

The Environmental Protection Group is trying to get accurate statistics on the number of vehicle accidents involving deer. The staff are collecting information on the nature of such accidents, whether the deer was injured, whether any people were injured and how much physical damage occurred. Please report any incidents, however minor, to Doug Arends, x4847 or arends@fnal.gov.

MILESTONES

RETIRED

Kathleen Cooper, ID # 108, from FESS, on December 31. Her last work day was December 5.

STORED AND EXTRACTED

First positron beam, in Italy's DAΦNE Accumulator, on November 19, 1997.

SI NON VIS IMPRIMI NOLI PATI FIERI
FERMINEWS MCMLXXVII

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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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