FERMI NEWS

FERMILAB A U.S. DEPARTMENT OF ENERGY LABORATORY

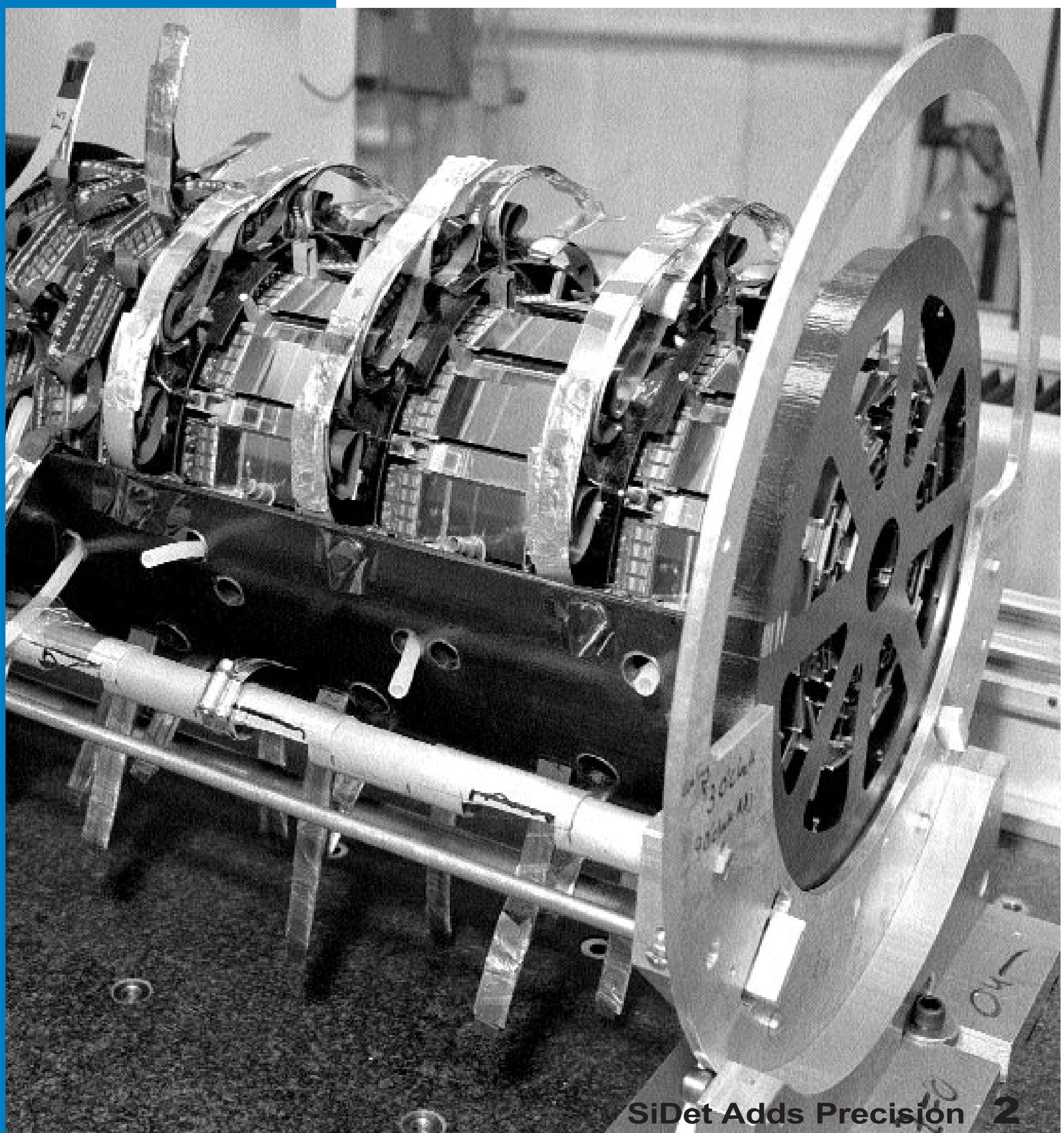

Photo by Reidar Hahn

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INSIDE:

SiDet Adds Precision

Photo by Jenny Mullins

Connecting tiny strips of silicon, a process called wirebonding, Sabina Aponte uses a microscope to identify the strips, located less than 60 microns apart.

by Kurt Riesselmann

They wear special clothing. They work with special machines. And they have special skills.

Employees at Fermilab's Silicon Detector facility must have the "right touch." Dropping a screw or making a wrong move can destroy a day's work—or even more. Operating expensive precision machines and handling delicate silicon wafers are a large part of their daily work. And on top of it all, they need to finish their projects on time. With Collider Run II just around the corner, experimenters rely on the dedicated expertise of the SiDet technicians.

"We were concerned whether we would be able to meet the tight schedule," said Jeff Spalding, project manager of the CDF silicon detector. "But the technicians at SiDet really exceeded our expectations." To his surprise, the pace of production was set by the delivery of components from the vendors.

Silicon detectors will be at the core of the upgraded CDF and DZero experiments, which will start operating in March 2001. Arranged in layers, the silicon devices record the tracks of particles escaping from high-energy proton-antiproton collisions. Tiny electronic chips amplify the signals created inside the silicon and transmit them to a computing unit that reconstructs the tracks.

Combining these results with data obtained from other devices inside the 50-foot-high CDF and DZero detectors, physicists are able to identify the types of particles produced and study their interactions. Using their improved detectors, physicists will obtain very precise information on the characteristics of the top quark, the heaviest elementary particle ever observed. Recent results also indicate that they have a chance of finding the Higgs boson, the key to explaining the origin of mass in our entire universe.

Producing silicon detectors is a science of its own. Physicists and engineers spent years designing and building small prototypes of the new detectors. To achieve their physics research goals, they used computer simulations to optimize the shape and location of the silicon wafers. Interestingly, the two collaborations favored different configurations.

COVER: Silicon microstrips and integrated chips are crucial components of high-precision tracking devices. The DZero microstrip detector features rectangular and wedge-shaped silicon pads, the latter pointing towards the central axis.

Fermilab's Marcel Demarteau (left) and Mikhail Merkin, Moscow State University, test the electronics of a wedge-shaped microstrip sensor, a critical component of the DZero silicon detector.

The CDF collaboration decided to base its entire silicon detector on rectangular silicon wafers that are assembled to form an open-ended barrel with five layers of silicon. A second construction, called the Intermediate Silicon Layer, will surround the barrel from the outside, separating it from the non-silicon detector components of the CDF experiment. In addition, the CDF scientists will insert a separate silicon assembly, called Layer 00, into the center of the 3-foot-long barrel. It will rest directly on the pipe that provides the vacuum environment for the Tevatron particle beams.

The DZero collaboration opted for both rectangular and wedge-shaped wafers. Similar to the CDF silicon detector, the rectangular pieces form the layers of a compact barrel. The wedge-shaped wafers are assembled into disks that look like pizzas with a shiny surface. These disks, large enough to cover the barrel openings, will sit perpendicular to the beam. A hole at their centers allows scientists to slide the disks right over the beam pipe.

The CDF and DZero scientists worked closely with four manufacturers to obtain silicon wafers that met the stringent experimental requirements. To determine the location of particle tracks to high precision, the silicon on the wafers is divided into microstrips, each less than one twentieth of a millimeter wide. By alternating the orientation of the strips and stacking them in layers, physicists obtain a precise three-dimensional map of the paths of all charged particles that cross the construction.

"To reduce the amount of material, the collaborations designed wafers with silicon strips on both sides," said Lenny Spiegel, associate leader of the SiDet facility. "The double-sided approach is more efficient, but handling is more difficult." Future projects, already underway at the SiDet facility, will return to using single-sided wafers.

Technicians, dressed in clean-room outfits, carefully inspect each silicon panel as they arrive from the manufacturer. To check the quality of the silicon microstrips, which are invisible to the naked eye, they use precision tools to measure the conductivity of all strips.

Designing the mechanical structure to support the wafers proved to be a crucial task. Physicists wanted to minimize the amount of material close to the collision area, since escaping particles would bounce off it. Yet the support structure needed to be stable enough to carry the weight and maintain the precise alignment of the wafers. These seemingly contradictory requirements resulted in the choice of thin carbon fiber rails as supports for the silicon wafers.

"It took a lot of prototyping," recalled Mary Morfin, who was involved in the rail production. To minimize the stress on the silicon wafers, which will rest on the rails, Morfin had to consistently produce rails that were "close to perfectly plane."

Gluing several silicon wafers next to each other on a single rail, technicians produced so-called ladders.

Photos by Reidar Hahn

The F-disk is a high-precision detector used inside the DZero detector to identify particle tracks. Lead technician Sharon Austin has been responsible for mounting the wedge-shaped silicon components.

"Aligning the silicon wafers to one another is a critical phase of the assembly process," said Bert Gonzalez, the lead technician for the construction of the CDF silicon barrel.

Gonzalez and his colleagues used precision measurement machines to determine the location of wafers to better than several thousandths of a millimeter.

Photo by Jenny Mullins

The support structure for the silicon ladders allows for installation of a cooling system. Cristian Gingu, from the Institute of Microtechnology in Bucharest, inspects the bulkheads for the SVX II silicon detector.

"We got the Zeiss precision machines, which cost $2.7 million in the 1970s, for a fraction of the original cost," said Greg Sellberg, who was responsible for the production of parts of the DZero silicon detector. "Looking for new equipment, I found them on a government surplus list."

Technicians normally use coordinate-measuring machines to check the alignment of a construction after its assembly. Sellberg and his colleagues retrofitted and maintained the machines so that the actual assembly of ladders could take place on them.

To modify the machines, physicists had to ask the Zeiss company to share the blueprints, a top industrial secret. Half an hour after DZero scientists called the company's CEO, the requisite fax arrived at Fermilab.

Once the ladders were assembled, technicians needed to electrically connect the silicon wafers to electronic chips by a process called bonding. Peering through microscopes, Tammy Hawke and her coworkers operated machines that fused aluminum wires, one-thousandth of an inch in diameter, to chips and individual silicon strips, producing a total of three million bonds.

"It takes about six months of training to learn the bonding process," said Ron Lipton, a co-leader of the DZero silicon detector efforts. "It takes the right personality, patience and hands."

The final assembly stage consisted of mounting the ladders inside a frame made of beryllium, a metal that is lighter but more stable than carbon. Attaching the ladders without breaking or scratching the silicon wafers required a steady hand. Only a few technicians had the skills to do the job.

"I had to use tweezers to place each screw, securing it with a nut," said Gonzalez, who installed all 180 ladders for the CDF silicon barrel. "I just couldn't afford to drop a screw inside the barrel since it could have done severe damage."

Physicists expected that it would take half a day to mount and align a single ladder in the barrel. Gonzalez greatly exceeded all expectations and, by the end of the project, was installing up to 12 ladders a day.

Last week, SiDet workers put the finishing touches on the silicon detectors. As the devices get moved to the collision halls inside the Tevatron, a ten-year project comes to an end.

"It has been a great team effort," said Spalding. "The technicians and everyone else have done a fantastic job." □

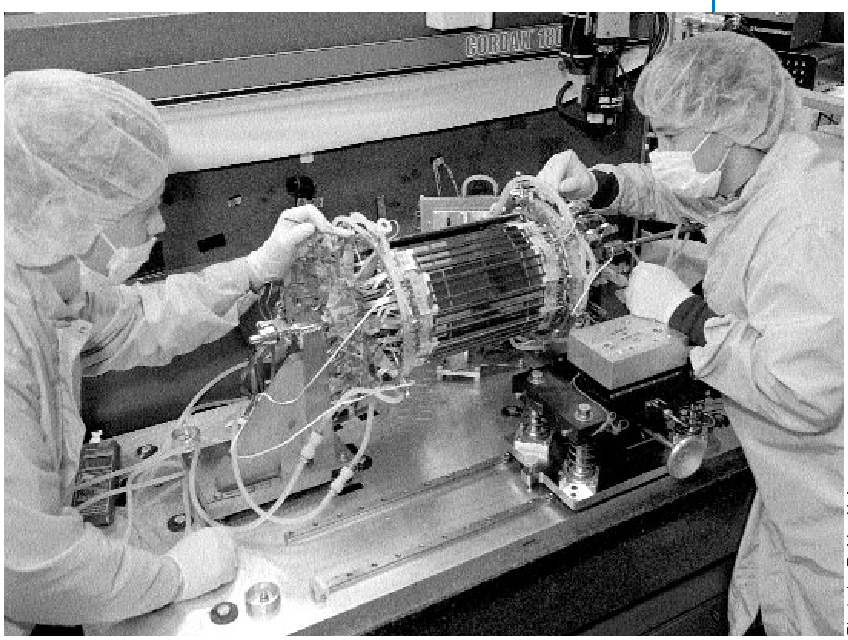


Photo by Reidar Hahn

Andrew Foland (left) and Bert Gonzalez work on the SVX II, an open-ended barrel with layers of rectangular silicon wafers. The SVX II will be installed in the CDF detector.

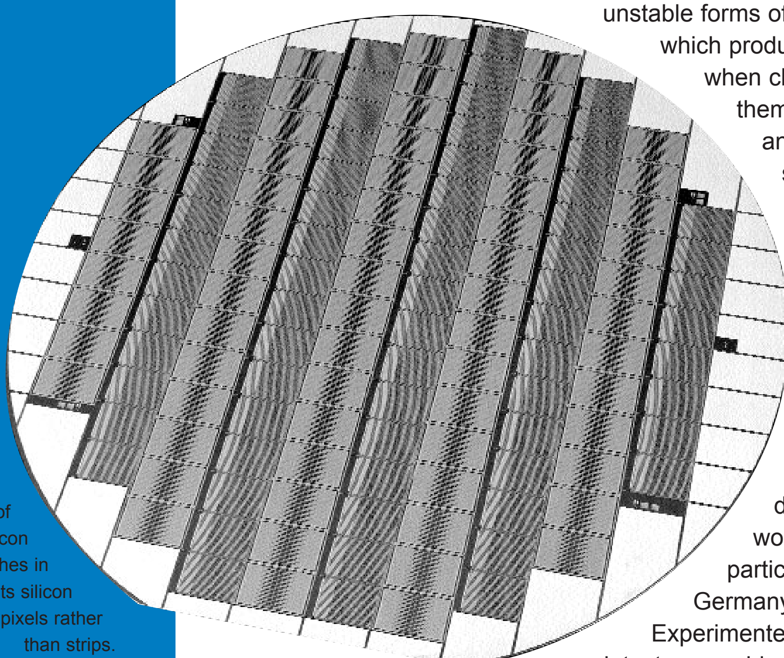
Silicon @Fermilab: Past and Future

by Kurt Riesselmann

In their quest to explore the microcosm, physicists have employed increasingly sophisticated tools to track particles, measure their energy and identify their decays. As they discovered twelve fundamental components of matter, the quarks and leptons, they met the challenge and created devices that differentiate among the variety of elementary particles produced in their experiments.

In the 1970s, the discovery of two heavy quarks, charm and bottom, began a new era of particle physics with unprecedented technological demands. Produced in high-energy collisions, heavy quarks decay within a tiny fraction of a second, traveling less than a few centimeters from their point of production.

To study properties like the lifetime and decays of these new particles, physicists needed compact, high-precision detectors to closely monitor the interaction point where particle beams create these unstable forms of matter. Thin slices of silicon, which produce an electrical impulse when charged particles fly across them, had become available, and physicists began exploring silicon's detection capabilities.



This protype of a BTeV silicon wafer, six inches in diameter, has its silicon divided in pixels rather than strips.

"The first silicon detectors were developed in the late 1970s," said Jeff Spalding, who took part in Fermilab experiment E691, the first Fermilab particle physics experiment to implement semi-conducting microstrip detectors. Its use of silicon detectors followed the R&D work carried out by European particle physicists in Munich, Germany and Geneva, Switzerland. Experimenters soon realized that silicon detectors would revolutionize the field by allowing for exploration of matter in greater detail.

"Silicon detectors offer extremely high spatial resolution," explained Spalding. "They opened a whole new realm of physics and precision measurements."

Placing layers of silicon sensors as close as possible to the interaction point is crucial to identifying particle tracks that originate from either charm or bottom quark decays. Tracing the signals caused by decay products back to their origin, scientists can determine the location of a particle's decay to secondary particles and calculate, for example, particle masses and lifetimes.

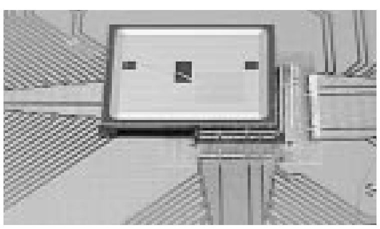
In the early 1990s, the CDF collaboration installed the first silicon detector in a colliding-beam experiment at Fermilab. To surround the almost two-foot-long interaction region with silicon sensors, physicists reduced the size of readout electronics and place it inside the space in which they also wanted to track

Silicon@Fermilab: Past and Future

particles. Using integrated chips, small electronic devices that amplify and transmit the signals created inside the silicon, scientists managed to solve the problem.

The success of CDF's first silicon detector, called SVX, encouraged physicists to design more sophisticated silicon devices and upgrade both the CDF and DZero detectors for Run II, set to begin in March 2001. They envisioned using the SVX technology on a much larger scale. Instead of the original 43,000 readout channels, a measure for the number of independent silicon strips, both CDF and DZero physicists made plans for silicon detectors with about 800,000 readout channels.

"It was clear that we needed a much larger facility to build these major upgrades," recalled Spalding. "In 1992, Lenny Spiegel and I went to the director and explained the need for a facility with large clean rooms and appropriate equipment."



This sensor, about 9 millimeters long, contains 18 columns of 160 silicon pixels each. Using bump-bonding, a prototype of the first-generation pixel read-out chip developed at Fermilab is attached from below.

This is one of the microscopic bumps sitting on top of a pixel read-out chip. It is used to connect a read-out channel to a 50-by-400-micron sensor pixel.

The idea for Fermilab's Silicon Detector facility was born. The Research Division (now Particle Physics) identified four old experimental halls, which at that time received more visits from birds and raccoons than from physicists, to host the new facility. Spiegel was responsible for revitalizing the buildings and setting up the SiDet facility.

Today, more than 6000 square feet of clean room with dozens of high-precision machines are dedicated to probe, mount and connect silicon strips; to outfit them with electronic chips; and to assemble all components into a compact structure that can be installed at the center of a state-of-the-art particle experiment.

"In our field, there is no other comparable facility," said Joe Incandela, the head of the facility. "We have the most space, the most machines. We can carry out each step necessary in the assembly of silicon detectors, and we can produce large volumes."

The true secret of the success, however, is the people working at the SiDet facility.

"The strength of SiDet is the cohesiveness of the people working here," said Spiegel, who is associate leader at the facility. "At peak times, about 100 people worked at SiDet: technicians, engineers, physicists, many visiting scientists from around the world. Their skills and knowledge have formed the basis for building the new silicon detectors for CDF and DZero."

Right now the SiDet facility is entering a transition period as it prepares for future tasks. The increased collision rate of the Tevatron collider will reduce the lifetime of the new silicon detectors, and physicists hope to replace them in 2004. In addition, Fermilab has agreed to construct one quarter of the silicon modules for the CMS experiment, scheduled to begin taking data in 2006 at the new Large Hadron Collider in Europe.

"We see a huge workload in the future," said Spiegel. He just ordered the first of two robots, developed at the European particle physics laboratory CERN, that will be used in mounting large quantities of CMS silicon strip wafers on support structures. Starting in 2001, SiDet workers will assemble about half of the 2500 square feet of silicon for the CMS detector. The rest is split among several European facilities.

In addition to silicon strips, the CMS experiment will also use new pixel technology. Instead of dividing silicon wafers in narrow bands of 50-micron width and several inches long, the new silicon wafers feature small rectangular-shaped areas of 150 by 150 microns. A single layer of silicon pixels provides more detailed information on where a particle traversed the panel.

"Presently, we have about 10 people working on the prototyping of the forward pixel detector," said Bruno Gobbi, professor at Northwestern University. He is part of the U.S.-CMS collaboration that is, among other projects, responsible for the design and construction of four 12-inch silicon pixel disks that will record particles leaving the collision area in the forward direction.

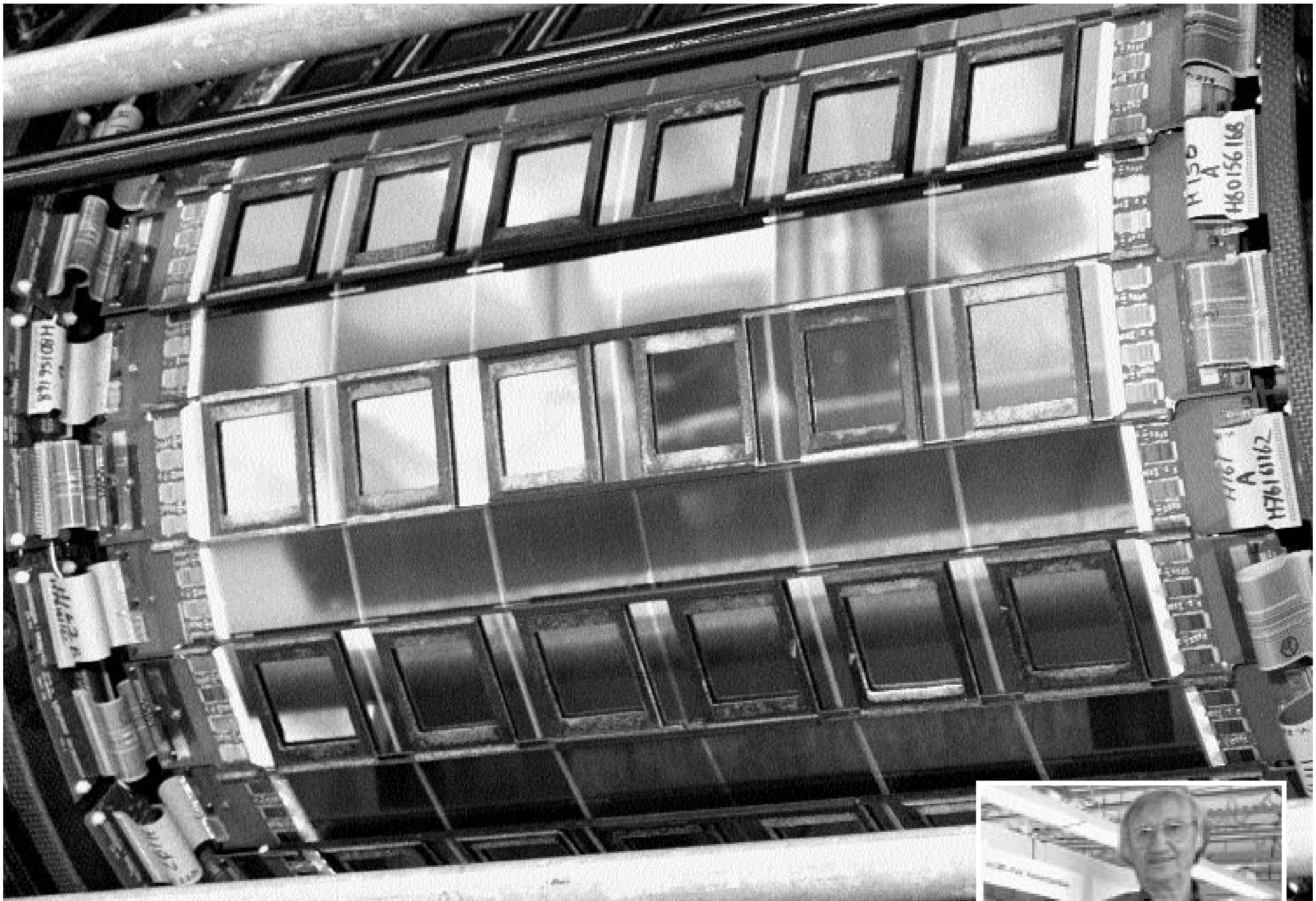


Photo by Jenny Mullins

The Intermediate Silicon Layer is one of three silicon systems built for the CDF experiment. Similar detectors will also be part of future high-energy physics experiments such as CMS and BTeV.

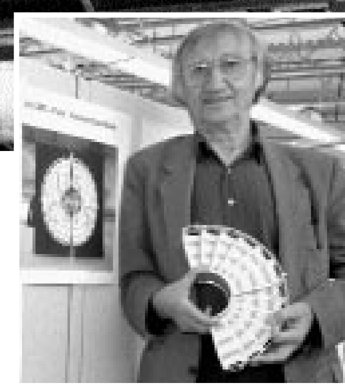


Photo by Reidar Hahn

The CMS collaboration uses the SiDet facility to develop next-generation silicon detectors. Fermilab's Muzaffer Atac shows a prototype.

SiDet's greatest challenge may come from Fermilab's future BTeV experiment, which will use the Tevatron beams to measure differences between properties of bottom quarks and antiquarks. If physicists obtain final funding, the experiment will begin operation in 2006.

"For the BTeV experiment, we expect the silicon pixel detector to have 31 million readout channels," said Simon Kwan, a physicist working on the BTeV pixel R&D program. "We aim at placing our silicon detectors closer to the Tevatron beams than any other experiment." At a distance of six millimeters, the detector will be more than twice as close as the CDF and DZero silicon detectors. The BTeV collaboration plans to be the first experiment to have silicon detectors *in* vacuum, separated from the primary beam only by a thin shield.

Placing silicon detectors close to the collision area puts enormous demands on the design of silicon devices, the supporting mechanical structures and the electronic readout equipment. All pieces, for example, must withstand high levels of energy transfer. Cooperating with research institutes around the world, Fermilab physicists are able to gather the necessary information about material properties.

The R&D efforts for both CMS and BTeV silicon detectors are centered at Fermilab's Silicon Microdetector laboratory, led by Greg Sellberg. Located inside the SiDet buildings, the lab provides the high-tech equipment for physicists to develop and test new silicon detector technologies.

"It is a juggling act if you have three projects going on at the same time," said Sellberg. "But you have to keep the users happy."

Preparing for future experiments, Sellberg and his colleagues will have many balls in the air in the years ahead. □

LEP Shutdown Throws Spotlight on Fermilab

“We did the best we could. We believe that it was a decision based on the scientific case.”

—CERN Director General Luciano Maiani

by Mike Perricone

While science usually moves in slow steps, the media likes a race. And thus the focus on the Higgs search was thrust upon Fermilab by the announcement on November 8 that the Large Electron-Proton collider had been turned off for the last time.

Director-General Luciano Maiani of CERN, the European particle physics laboratory in Geneva, Switzerland, said LEP’s one-month extension had ended with its Nov. 2 shutdown. Maiani acted despite pressures from CERN experimenters for a year-long extension to follow up on “tantalizing” hints for evidence of a Higgs particle at a mass of 115 GeV/C^2 announced near the end of LEP’s 11-year run.

“We did the best we could,” Maiani said. “We believe that it was a decision based on the scientific case.”

LEP experimenter Chris Tully of Princeton, one of those who had pleaded for more time in Geneva, was widely quoted when he said: “Fermilab is clearly the next up to bat.”

Then the phones started ringing in Batavia, asking about the search for the Higgs boson, reputed to be the source of all mass since its postulation by Scottish physicist Peter Higgs about 35 years ago.

CERN’s long-planned transition from running the LEP to constructing the Large Hadron Collider, concurrent with Fermilab’s firing up for Collider Run II of the Tevatron in March 2001, took on media elements of a fierce race to the Higgs finish, with one competitor (CERN) forced out prematurely, and the other (Fermilab) now having a clear field ahead for the discovery and a shot at a Nobel Prize.

Photo by Jenny Mullins

CERN Director General Luciano Maiani

As always, reality wasn’t so simple.

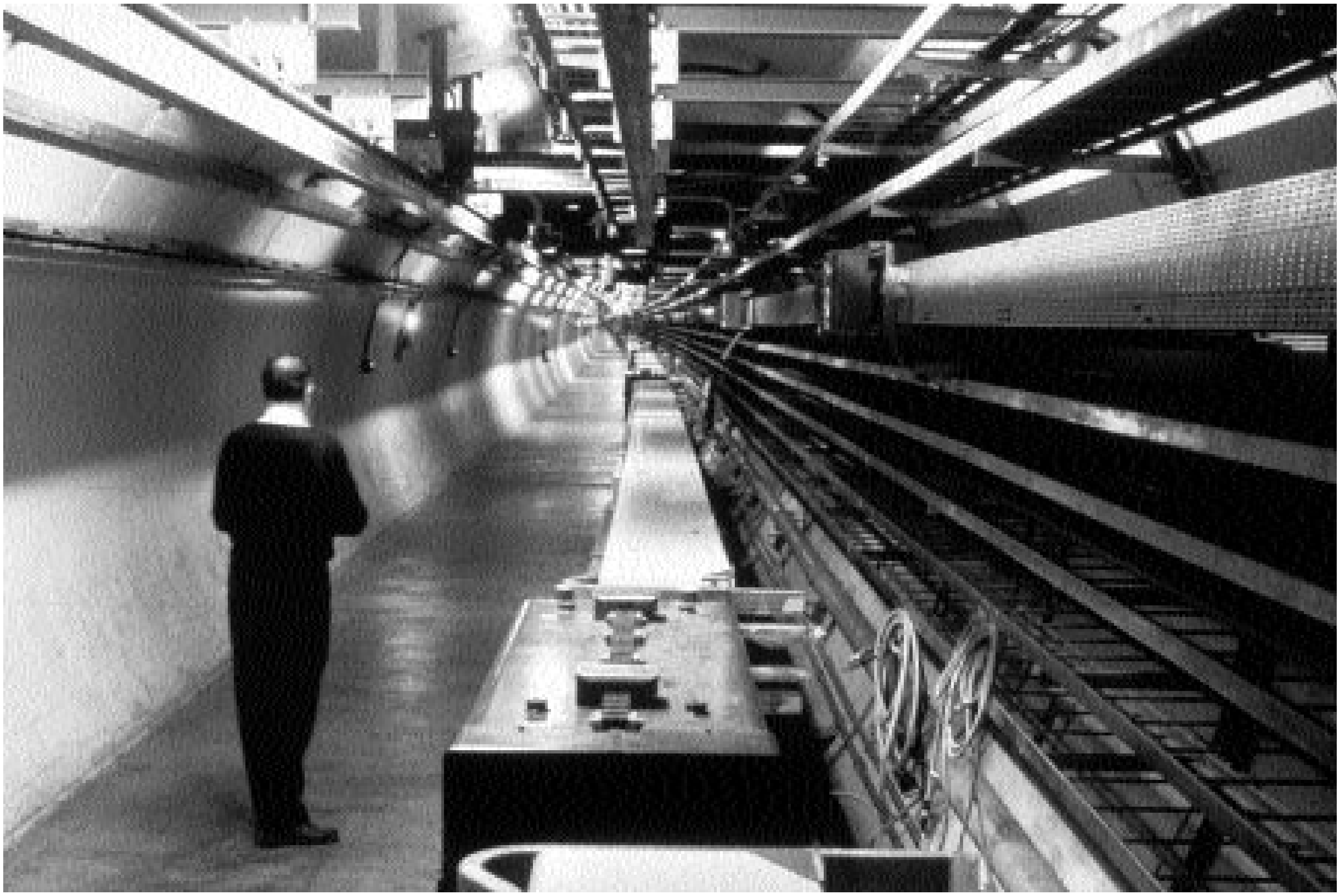
Maiani faced huge added expenses both for prolonging the LEP run (perhaps $60 million) and for delaying the schedule of the LHC.

“Since the next step is so expensive, we had to stop at this point,” he said.

Experimenters continued to exert pressure after the announcement, and Fermilab Director Michael Witherell was sympathetic to Maiani’s dilemma.

“It really is a decision in which you can’t be absolutely sure you’re doing the right thing,” Witherell said, “because you don’t have the right information.”

Extending LEP would have meant delays in the LHC, creating ripple effects at Fermilab, a major supplier of components for the next-generation accelerator and detectors, as well as a major experimenter in the LHC era. Jim Kerby, project manager for LHC magnet production at Fermilab, saw little if any impact; work on completing the accelerator components is moving as quickly as possible, independent of the LEP situation.



CERN Photo

All good things come to an end, even the impressive 11-year run of the LEP at CERN. This same tunnel will house the LHC.

But Dan Green had serious concerns over possible rescheduling. Green is Project Manager for the US/CMS collaboration, working on the Compact Muon Solenoid detector for the LHC. Fermilab is the host laboratory for the US/CMS effort, as well as the host lab for software and computing and the research program, including maintenance and operations.

"It would have been bad," Green said of possible LHC delays. "There are penalty clauses in the contracts for the experimental halls which would, ultimately, take money away from the experiments. There would be delays in beneficial occupancy of the experiments. And there would have been a critical delay in the start of the CMS physics program."

Yet the combination of events underscored these realities in Fermilab's future:

- Fermilab does have the field to itself at the high-energy frontier, until the LHC begins operation later this decade;
- if CERN has established a Higgs mass region around 115 GeV/C^2 (the jury is out), the particle might be within the experimental reach of the Tevatron in Collider Run II;
- with uncertainty characterizing Fermilab's prospects in the LHC era, the stakes couldn't be higher for Collider Run II.

"It's extremely important for our future to demonstrate what Fermilab can do," said John Womersley, co-spokesman of Fermilab's DZero collaboration. "We must make the most of this opportunity. It may never happen again."

Fermilab's 5,000-ton detectors, DZero and CDF, will stage their own intralab rivalry to track down the Higgs if it's there to be found in Run II. But Womersley and CDF co-spokesman Franco Bedeschi both prefer to a talk about seeking a Higgs "mechanism," rather than a single Higgs particle. They agree that the mass-producing property might be the function of more than one type of Higgs particle, or, for that matter, an assortment of particles that includes a Higgs. Those scenarios could strengthen the theory of Supersymmetry; or they could buttress the theory called Technicolor; or they could give rise to ideas that haven't yet been formulated.

"When we talk about a 'hunt for the Higgs,'" said Bedeschi, "we actually mean the entire Higgs mechanism, because there are many ways

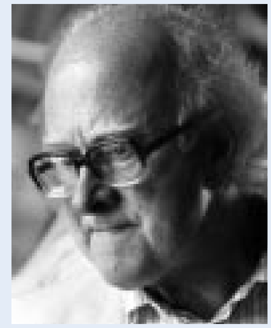
Eyes on The Prize?

Fermilab's CDF and DZero detectors total more than 1,000 collaborators. Strictly conjecture, of course, but if a Higgs particle shows up, how would the Nobel Prize committee settle on a nominee? Who gets the credit?

"I'd like to say that it was discovered at Fermilab, not necessarily at one detector or the other," said DZero co-spokesman John Womersley. "And would accelerator people be left out, simply because they did not publish a paper? Obviously, we could not make a discovery without the people who make the accelerators work."

Another possibility:

"Maybe they would give it to the theorist for predicting it in the first place," shrugged CDF co-spokesman Franco Bedeschi.



Peter Higgs

That would be Peter Higgs, who in 1964 was among the earliest to theorize that some unknown particle breaks the symmetry of empty space. This ripple-like Higgs field imparts energy, and thus mass, to particles that cross the ripples. Particles such as photons, traveling along the ripples, remain massless.

Harry Weerts, Womersley's co-spokesman at DZero, offered a light-hearted compromise.

"I think they should give the Nobel to the experiment spokesmen," he said.

it could operate. In some ways, it would create more meaningful physics if it's more than just one particle that has all the qualities we're looking for."

"A lot of people actually would be surprised if we found one Higgs particle with all the qualities predicted for it," Womersley concurred. "That would, in some ways, be an anticlimax."

They lean differently on the LEP "hints." Womersley credited CERN experimenters with making a strong case for extending the run, while Bedeschi doubts that LEP saw the Higgs.

During its one-month extension, LEP surpassed its design expectation of 200 GeV collision energy, reaching 209 GeV before the shutdown. Womersley said the LEP radiofrequency cavities began heating up, effectively setting the final upper boundary for the accelerator.

At the Tevatron in Run II, Bedeschi said a five-year experimental run would yield about 5×10^{14} collisions, of which about 3,000 might be candidates for a Higgs particle with 115 GeV/C^2 mass. Fermilab's two detectors have their best shots at seeing a Higgs particle in two energy ranges: at around 120 GeV/C^2, and at around 160 GeV/C^2, depending on the value of the particle's mass compared to that of the W boson mass.

The search for the Higgs has always been a priority of Run II, although the science program has also emphasized the exploration of CP violation in the physics of the bottom quark; increased production and precision measurement of top quarks; and possible observation of supersymmetry particles. After years of construction and upgrades, Bedeschi and Womersley accurately represent the eagerness throughout the lab to get back to "doing physics" and possibly matching such past achievements as the discovery of the bottom (1977) and top (1995) quarks.

Bedeschi recalls the frustration of the 1980s, a tight time for funding, when Fermilab watched CERN create the first proton-antiproton collisions, leading to the Nobel Prize-winning production of the W and Z particles by Carlo Rubbia and Simon Van Der Meer.

"I think we could have competed with CERN for those discoveries if we had had the budget," Bedeschi said.

The budget is always a factor: CERN's annual budget of 1.1 billion Swiss francs converts to about $617.7 million. Congress recently approved $726 million for the entire U.S. high-energy physics program in FY2001, including $277 million for Fermilab. But in March, 2001 Fermilab will continue the search on its own.

"We've had to watch the last two years while LEP was running and coming tantalizingly close to the Higgs," said Womersley. "It was like standing outside the restaurant, looking through the window and watching others have dinner. Now it's our turn." □

‘Desperate Remedy’ Hits the BIG SEVEN-O

by Mike Perricone

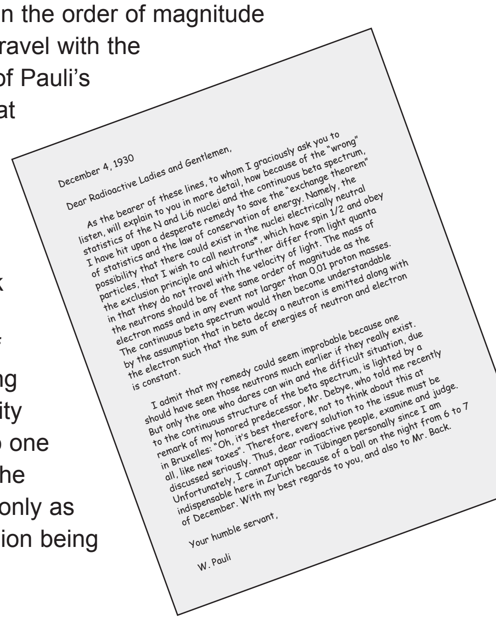
Fermilab Photo

Wolfgang Pauli

By all accounts, Wolfgang Pauli was the kind of physicist who could claim with equanimity that he would save the law of conservation of energy.

He did exactly that, in his famous letter dated December 4, 1930, and addressed to “Dear Radioactive Ladies and Gentlemen.” Unable to attend a conference in Tubingen, Germany, Pauli sent the letter to his colleagues outlining what he called “a desperate remedy” to the perplexing phenomenon in beta decays that produced electrons with a range of energies instead of a single energy every time.

Pauli proposed electrically neutral particles (he called them “neutrons”) in the nucleus, with spin of 1/2 and mass on the order of magnitude of the electron mass, and which do not travel with the velocity of light. The first public hearing of Pauli’s particle proposal came six months later at a meeting of the American Physical Society in Pasadena, California. Enrico Fermi eventually renamed the particle the neutrino.



December 4, 1930

Dear Radioactive Ladies and Gentlemen,

As the bearer of these lines, to whom I graciously ask you to listen, will explain to you in more detail, how because of the “wrong” statistics of the N and Li6 nuclei and the continuous beta spectrum, I have hit upon a desperate remedy to save the “exchange theorem” of statistics and the law of conservation of energy. Namely, the possibility that there could exist in the nuclei electrically neutral particles, that I wish to call neutrons*, which have spin 1/2 and obey the exclusion principle and which further differ from light quanta in that they do not travel with the velocity of light. The mass of the neutrons should be of the same order of magnitude as the electron mass and in any event not larger than 0.01 proton masses. The continuous beta spectrum would then become understandable by the assumption that in beta decay a neutron is emitted along with the electron such that the sum of energies of neutron and electron is constant.

I admit that my remedy could seem improbable because one should have seen those neutrons much earlier if they really exist. But only the one who dares can win and the difficult situation, due to the continuous structure of the beta spectrum, is lighted by a remark of my honored predecessor, Mr. Debye, who told me recently in Bruxelles: “Oh, it's best therefore, not to think about this at all, like new taxes”. Therefore, every solution to the issue must be discussed seriously. Thus, dear radioactive people, examine and judge. Unfortunately, I cannot appear in Tübingen personally since I am indispensable here in Zurich because of a ball on the night from 6 to 7 of December. With my best regards to you, and also to Mr. Back.

Your humble servant,

W. Pauli

A 1930 letter from Wolfgang Pauli to colleagues in Tübingen, Germany described a “desperate remedy”.

About 25 years later, T.D. Lee and Frank Yang of Princeton said there might be some funny business in the symmetry of beta decay. Soon thereafter, Chien-Shung Wu and colleagues at Columbia University found beta decay electrons all coming to one side instead of spraying out uniformly—the result, it appeared, of neutrinos existing only as left-handers, with their right-handed version being the antineutrino.

“Happy Birthday, Lefty?” Not so fast.

“Speaking as a left-hander, I like the idea of celebrating that aspect of neutrinos,” said MINOS collaborator Peter Lucas of Fermilab. “However, if they have even a small mass, they also must have a small right-handed component.”

“As far as we know, left-handed neutrinos and right-handed antineutrinos both have ‘normal’ weak interactions,” said Bill Louis, co-spokesperson for MiniBooNE. “There could exist right-handed neutrinos that are ‘sterile’ and left-handed antineutrinos that are ‘sterile.’”

Either way, Pauli probably wouldn’t serve as the life of the party for any Big Seven-0 celebration. According to *The Search for Infinity* (Gordon Fraser, Egil Lillestol, Inge Sellevag; Facts on File; $23.95), renowned physicist Victor Weisskopf recalls finding a mistake in one of his own published calculations, and asking Pauli, his teacher, whether he should give up physics.

“Don’t,” Pauli responded. “Everyone makes mistakes. Except me.” ☐

Northern LIGHTS

Physicists from Dubna Laboratory in Russia and Sweden's Stockholm University PLAY KEY ROLES for Run II at CDF and DZero

by Judy Jackson

Stockholm is every physicist's dream destination. That's where they pass out the Nobel Prizes.

But for some Stockholm physicists these days, Fermilab is the destination of choice. That's where they pass out the high-energy protons.

As Fermilab's detector collaborations race to prepare for the upcoming collider run at the Tevatron, physicists from Sweden's Stockholm University are among the dozens of collaborators hard at work on DZero's Silicon Vertex Detector, assembling and installing the intricate marvel of leading-edge technology that will operate at the heart of that collaboration's 5000-ton detector. They are among the many hundreds of scientists from institutions in 16 nations who have joined in the physics adventure called Run II, at the energy frontier.

Meanwhile, around the Tevatron ring at CDF, another northern contingent, this one from the Joint Institute for Nuclear Research, in Dubna, Russia, 130 kilometers north of Moscow, watched with satisfaction this fall as the eight tons of scintillation counters that they built and delivered to Fermilab passed the test of CDF's recent commissioning run with flying colors. Six hundred and seven units of scintillating counters made of fibers from the Ukraine, assembled in Russia and air-freighted to Fermilab, are now an integral part of the $100 million CDF upgrade that researchers hope will discover new knowledge about what the universe is made of and how it works.

Why have these scientists come from their lands of snowflakes and birch trees to our land of snowflakes and protons? Hint: It's not the snowflakes.

It's simple, said Julian Budagov, leader of the CDF Dubna group.

"The Tevatron is the best place to continue the study of matter."

Barbro Åsman, of Stockholm University, agreed.

"For high-energy physicists," she said, "Run II at the Tevatron will produce the most interesting physics in the world, for at least the next five years."

Åsman is eager to ensure that Swedish physicists and graduate students have access to the discovery opportunities that data from the Tevatron will provide. Besides collaborating on Fermilab's DZero experiment, Stockholm is also a member of DELPHI, one of four collider experiments at the Large Electron Positron Collider at CERN, the European Laboratory for Particle Physics. However, a recent statement from CERN's Committee of Council that "terminates the LEP data-taking and moves us into the LHC era," means that DELPHI's data-taking days are now over. The half-dozen years before high-energy collisions at CERN begin again at the Large Hadron Collider are too long for thesis-bound students to wait. So, like hundreds of their fellow physicists worldwide, they have decided to come to Fermilab, where, starting next March, high-energy protons will once again be blazing a trail to the heart of matter.

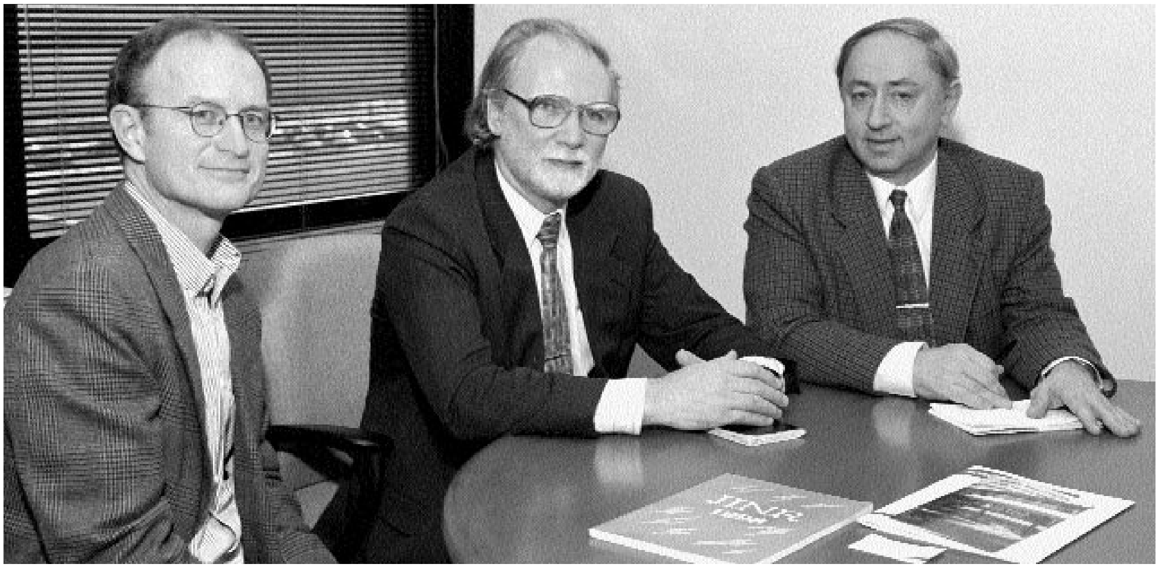


Photo by Reidar Hahn

Dubna Director Vladimir Kadyshevsky (center) and Vice Director Alexej Sissakian during a recent visit to Fermilab Director Michael Witherell.

The Stockholm researchers will concentrate their Run II analysis efforts on the search for Supersymmetry, Åsman said, although “exactly where we haven’t figured out.” She expects that as many as 12 Swedish physicists and students will ultimately become DZero collaborators.

At CDF, Budagov said, the Dubna group will concentrate on the physics of the top and b quarks. Besides the better-known Higgs and SUSY searches, experimenters expect that the new capabilities conferred by CDF’s SVX silicon detector, to which Dubna scientists contributed, will open up exciting new vistas in b physics for Run II. The Dubna group of about seven scientists and students can hardly wait to get started.

“We’ll be working night shifts, day shifts, 120 percent,” Budagov said. “New physics is target number one.”

Dubna, the home of the Joint Institute for Nuclear Research, has a proud tradition of forefront research in the physical sciences, and in fact Dubna scientists also collaborate at DZero. Budagov wears a watch commemorating the 50th anniversary of accelerator operation at the laboratory, located at the confluence of the Volga, Dubna and Sestra Rivers. In a symbol of the survival of experimental physics through difficult times, that 50-year-old accelerator, the 680 MeV synchrocyclotron, once the world’s most powerful particle accelerator, is still operating today.

Budagov described JINR, founded in 1956, as a sort of Eastern Bloc version of CERN, with member states including Russia, Ukraine, Belarus, Armenia, Kazakhstan, Uzbekistan, Azerbaijan, Poland, Georgia, the Czech Republic, Bulgaria, Slovakia, North Korea and, most recently, Vietnam, among others. The Dubna laboratory currently operates active programs in particle physics, nuclear physics and condensed matter physics.

After a number of extraordinarily difficult years for physics research in Russia and other former Soviet member states, the future of JINR at Dubna is now looking somewhat brighter. A January 2000 law recognized JINR as an international organization on Russian soil and provided for significant ongoing financial support from the Russian government. Member states contribute to its operation.

Scientists from JINR are active on forefront physics experiments worldwide. But just how did Dubna scientists wind up at CDF?

“Everything starts with friendship, with personal relationships,” Budagov said. Collaborations at Brookhaven National Laboratory and at the late lamented Superconducting Super Collider led to friendships and working relationships among Dubna scientists and American physicists, and to an especially close collaboration with Italian physicists from Pisa, who are themselves charter CDF members.

“We came to CDF through the Dubna-Pisa connection,” Budagov said. “Science brings nations together.”

At DZero, Stockholm’s Åsman echoes his sentiments.

“For us, DZero feels like a good fit,” she said. “We’re from Sweden, but we feel very much at home at Fermilab.” ☐

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The Mom Test

This fall, *FERMINEWS* lost one of its most devoted readers. My mom. Until she died on September 19, she read every word of every issue.

My mother loved physics. To her, the idea that the grandeur of the universe could be understood in terms of physics was profoundly satisfying—even thrilling. And Fermilab, where she often visited, was Physics Central.

There's a sort of unofficial test, "the Mom Test," that scientists and science writers often use to gauge the clarity of their explanations to the public: Would my mom understand what I am saying? Have I explained neutrino masses and mixing so simply that my mother would understand neutrino oscillation? Can I lay out electroweak symmetry breaking in such lucid terms that Mom will know the Higgs boson when she sees it?

I don't think I passed the Mom Test with my mom. I think she understood hardly anything I ever wrote or explained about physics. Not that I didn't try. But Mom didn't really want to get into what she regarded as the details. To be honest, I don't think she knew $F=ma$ from a ham sandwich, but she didn't care. She thought physics was wonderful just the same.

Mom looked on physics in a more or less mystical way, as a sort of spiritual undertaking. Her bookshelf held every book of popular physics and cosmology published in the last 30 years. She read Leon Lederman's *The God Particle* the way mothers of other persuasions read Holy Scripture; and no biblical prophet ever enjoyed greater veneration than my mother felt for its author. She loved Brian Greene's *The Elegant Universe*; she was nuts about string theory. And let's not forget Saint Stephen Hawking.

I once suggested that, since Mom found physics so exciting, she might like to sign up for Physics 101 at the local community college.

"Oh no," she said, "I don't want to understand it. I just want to know what it *means*."

For a long time, Mom's mystical approach to physics annoyed me. It seemed to me she loved physics for something it wasn't, and not for what it is.

"It doesn't *mean* anything," I told Mom. "It's all *about* understanding. Physics isn't religion, it's science."

"I know, dear," she said, "but remember that Einstein showed us that all truth is relative."

See what I mean?

But Mom was an evangelizer. She spread the gospel of physics throughout the southern Vermont community where she lived. She put all her friends and acquaintances on the *FERMINEWS* mailing list. Thanks to my mom, Windham County, Vermont is a bastion of hard-core support for Fermilab physics. Since Fermilab physics can use all the friends it can get, I began to take a more lenient view of Mom's approach to the subject. It doesn't do to be too picky.

We held my mother's memorial service on October 12. It would have been her 80th birthday. The church was packed with those who had known her, many of whom rose to speak about her.

Toward the end of the service, a man stood up to talk about Mom's pride in her children.

"She talked about them all the time," he said. "She was especially proud of her daughter in Illinois who discovered the Higgs boson."

Aw shucks, it was nothing.

As I said, Mom loved *FERMINEWS*. She read all the stories, but she liked mine best. I know, because she told me so.

—Judy Jackson

CALENDAR

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

Brown Bag Seminar:
Physics For Everyone

Dec. 12

Want to know more about what we really do here at Fermilab? This monthly series is for you. Next presentation: Linda Spentzouris of the Main Injector Dept. speaks on accelerators, Tues., Dec. 12, noon to 1 p.m., Wilson Hall-One West. Future topics will include detectors, symmetry, the Higgs, cosmology, Sloan Digital Sky Survey, and dark matter, and we hope to add more topics to the list. Questions? Call Roy Thatcher, x8364. Theorist Chris Quigg's Nov. 14 presentation, *"Particle Physics: The World of Matter, Space and Time"* is available at the Visual Media Services website http://www-visualmedia.fnal.gov.
Click on "Services Offered," "Video Production," "Streaming Video" and "Physics for Everyone."

ONGOING
NALWO

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

■ Coffee for newcomers & visitors, Thursday November 30 at Housing office (Aspen East) 10:30 a.m.-12 p.m.

DANCING

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

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

■ The Fermilab Barn Dance series, featuring traditional square and contra dances, takes place every second Sunday evening at 6:30 p.m., Village Barn. Come with or without partner and family. Admission: $5 for adults, $2 age 12-18, free for under 12. For information contact Dave Harding, x2971 or Lynn Garren, x2061, or check the webpage at www.fnal.gov/orgs/folkclub/.

LAB NOTES

■ Travel Office will be closed the entire day on Dec 22 and Dec 29.

■ The 2001 Social Security Wage Base will be $80,400. This is a Base increase of $4,200 over calendar year 2000. The tax rate will remain at 6.2% so the tax increase will be $260.40 for employees exceeding the Base. Medicare does not have a base limit and the 1.45% rate is unchanged for 2001.

■ The Payroll Department will be closed from 12/22/2000 to 1/2/2001. Time and Leave Sheets will be requested early. Monthly paid employees will be paid on 12/21/2000 and Weekly employees who turn in Time Sheets for W/E 12/17 and 12/24 will also be paid on 12/21/2000. Questions should be directed to the Payroll Department on extensions 3046, 2991 or 2992.

CORRECTION

In "MiniBooNE Ready to Move In" (*FERMINEWS*, Vol. 23, No. 19) the source of the neutrino beam for the MiniBooNE experiment was misidentified. The beam is obtained by using an 8 GeV proton beam from Fermilab's Booster accelerator. Also in the story, Peter Kasper's job description was incorrect. He is the project leader for the civil construction of the MiniBooNE detector and its enclosure. *FERMINEWS* regrets the errors.

Chez Léon MENU

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

Dinner served at 7 p.m.
$20/person

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

LUNCH
Wednesday, December 6

Orange Game Hens
with Cumberland Sauce
Wild Rice and Pecans
Vegetable of the Season
Brandied Pear and Currant Strudel

DINNER
Thursday, December 7

Beef Fondue
with Assortment of Sauces
Salad of Field Greens, Apples
and Walnuts
Hazelnut Torte
with Frangelico Créme Anglais

LUNCH
Wednesday, December 13

Raspberry Chicken
Sauteed Peapods and
Julienne of Red Pepper
Green Rice
Linzertorte

DINNER
Thursday, December 14

Chestnut Soup
with Cognac Cream
Steamed Lobster Tails
with Champagne Butter Sauce
Vegetable of the Season
Spinach Salad with Pomegranate
Xmas Pudding
Assortment of Cookies

FERMI NEWS

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The deadline for the Friday, December 15, 2000, issue is Tuesday, December 5, 2000. Please send classified ads and story ideas by mail to the Public Affairs Office, MS 206, Fermilab, P.O. Box 500, Batavia, IL 60510, or by e-mail to ferminews@fnal.gov. Letters from readers are welcome. Please include your name and daytime phone number.

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CLASSIFIEDS

FOR SALE

- '98 Dodge Dakota Sport one owner 4x4. King Cab - bed cover - excellent condition - 46,000 miles, $18,500. Sam 815-439-0460.
- '94 Honda Accord EX wagon, 63K miles, 5-spd. stick, fully-equipped (sun roof, CD, A/C, cruise, etc.). Exc. cond. $10,000. Call Joe Lach, X4103.
- '93 Lexus ES300, 75K miles, 6 disc changer, tinted glass, sun roof, leather, all the goodies. $12,500 Call Ed Dijak ext 6300 or dijak@fnal.gov, home 630-665-6744.
- '89 Toyota 4Runner 4X4, silver, 60K miles, excellent conditions asking $5,700. obo, call 898-6878.
- '85 Z-28 Camaro, new starter, water pump, strong runner 100K+, AM/FM, CD, good tires mag wheels, new brake line, asking $2,600 obo. 630-393-6744
- '81 Suzuki GS 12000 LX, 30L+ new battery, plugs, oil, hardware. Needs TLC $1,000 obo, 630-393-6744.
- Townhome, Wheaton, close to Danada, I-88 & I-355, access to clubhouse, pool & tennis court, 2 BR, 1 BA, master bdrm (14 x 10) has huge walk-in closet, living rm (18 x 12), dining rm (9 x 8), newer kitchen (13 x 9), 1-car attached garage, new dishwasher & water heater. Asking $112,500. Call 630-871-9235, MDP1116@aol.com.
- Unique 2 story house in Batavia built for "in-laws" or 2nd family. 1st and 2nd stories alike (kitchen, 3 bedrms, living & dining rms); 1st floor accesses finished basement (laundry, rec.rm.,office); 2nd floor has laundry, fireplace, deck with stairs to yard. .8 acre lot with beautiful mature landscaping. Reduced asking price $249,000. Contact asfishman@aol.com or 630-262-6566
- 1970-80's rock albums, very good condition 630-393-6744.

WANTED

- Folding/Utility or craft table. Call x6633.
- Loving stay-at-home Mom (experienced teacher) willing to watch your child in her Plainfield home. Hot nutritious meals, personal attention, learning environment, siblings welcome. Call Kris at 815-439-0460.
- Room for rent on independent floor with living shareable; one car garage and use of kitchen and laundry, in calm residential Naperville 395./month call 840-2574

BIBLE STUDY

You are invited to experience a one-year course through all 66 books of the Bible. Every Wednesday at noon, 1/2-hour session meets in the Huddle. Jeff Ruffin x4432, ruffin@fnal.gov

MILESTONES

HONORED

With Fermilab Employee Recognition Awards, presented by Fermilab Director Michael Witherell on Nov. 15: **Ray Yarema** (ID 1084 PPD-Engineering and Tech. Teams), for his continuing development, leadership and management of the Application Specific Integrated Circuit (ASIC) group in the Research and Particle Physics Division; **Byron Lundberg** (ID 07761, PPD-Exp. Physics Projects), for his leadership and management of the effort in the past seven years in the design, construction, operation and data analysis of the DONUT experiment; **Bruce Baller** (ID 07525N, PPD-MINOS) for his work in the past five years in the operation and data analysis of the DONUT experiment; and **Regina Rameika** (ID 05652N, PPD-Exp. Physics Projects), for her leadership during the past seven years in the design, construction, operation and data analysis of the DONUT experiment.

NAMED

To the new President's Science and Technology Advisory Committee in Taiwan: **G.P. Yeh** (ID 06874N, CD-CDF Computing and Analysis), for his work in the observation of the top quark, and in computing at CDF. The Committee is organized by Taiwan president Chen Shui-bian and chaired by vice president Shih-Chien Yang.

ELECTED

As a Fellow of the Royal Institution of Chartered Surveyors of the United Kingdom: **Babatunde O'Sheg Oshinowo** (ID 10686 PPD-Technical Centers) of the Alignment and Metrology group; on Nov. 1, 2000.

http://www.fnal.gov/directorate/public_affairs/ferminews/

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