FERMI NEWS

FERMILAB A U.S. DEPARTMENT OF ENERGY LABORATORY

Photo by Fred Ullrich

SPECIAL ISSUE: TEVATRON AT 20

Volume 26
November 2003
Number 15

INSIDE:

20 Tevatron

Happy Anniversary, Tevatron!

by Mike Witherell

I remember well waiting for news of the first beam from the Energy Doubler, later to be known as the Tevatron. I was working with a group of about 35 physicists writing a proposal to do the first high-statistics, low-background charm experiment using the new technology of silicon microstrip detectors. We planned to use the higher energy photon beam that could be made starting with 800 GeV protons from the Tevatron. The news in the summer of 1983 that 512 GeV protons were produced gave us great encouragement that a superconducting accelerator would really work. Meanwhile Fermilab was breaking ground for the Antiproton Source, getting ready to start a new program based on antiproton-proton collisions inside the Tevatron.

In the twenty years since those record-setting protons were extracted from the Tevatron, thousands of physicists have advanced our understanding of nature using this spectacularly successful instrument. The top quark was the signature discovery that justified by itself the initial investment. But physicists also used the Tevatron to observe the first tau neutrinos, to measure proton structure with muons and neutrinos, to understand the nature of CP violation in K meson decays, to measure the lifetimes of particles containing charm and bottom quarks, and to search for new physics at the highest energies.

Today, the Tevatron is still the highest-energy accelerator in the world. We are now operating the Tevatron at a luminosity 40 times its initial design value, and we'll see further improvements. The accelerator is today the only operational machine to study top quarks and W bosons. The CDF and DZero collaborations will be studying data samples from Run II that are fifty times as large as in Run I. They will use these samples to look for the next big discovery—supersymmetry, extra dimensions, or something that we have not imagined yet.

The Tevatron is also a superb instrument for exploring the properties of Fermilab's first great discovery—the bottom quark. CDF and DZero are the only experiments able to look at properties of the B_s meson, not well studied because it is inaccessible at the B-factories. The new BTeV experiment will push the study of B physics to new levels of sensitivity, orders of magnitude beyond current experiments. It will keep the Tevatron at the frontier of science ten years from now.

For twenty years the Tevatron has helped us to understand the nature of the universe we live in—and it continues to do so.

COVER PHOTO: The Main Control Room on Sunday, July 3, at 3:37 p.m. as the Tevatron accelerated protons to 512 GeV, a new world record for accelerators.

ON THE WEB:

Discoveries at Fermilab
www.fnal.gov/pub/inquiring/physics/discoveries/

The Tevatron Fixed-Target Program
http://conferences.fnal.gov/tevft/book/

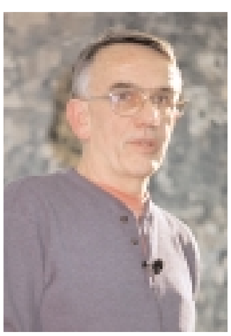
Fermilab Experiments
www.fnal.gov/faw/fermilab_at_work.html#experiments

Photo by Reidar Hahn

Aerial view of the Tevatron and the adjacent Main Injector ring.

Twenty years at the energy frontier

by Paul Grannis



So, the Tevatron is turning 20—leaving the adolescent teenage years and passing into maturity.

The Tevatron began operations in late1983 when the E715 experiment initiated the use of the world's highest-energy beams. Since then more than forty fixed-target experiments have used Tevatron beams of protons, pions, muons, photons, hyperons and neutrinos to expand our knowledge of particles and forces. These experiments were bewilderingly—to the non-initiated—named by experiment numbers. Somewhere around E800, more descriptive names of experiments became common.

Through several fixed-target experiments we have learned much about particles containing charm and bottom quarks, and have greatly improved our understanding of the distributions of quarks, antiquarks and gluons within the proton and neutron. It took years of data taking and analysis to explore the small difference of particle interactions between matter and antimatter, known as CP violation. Investigating K meson decays, the KTeV collaboration helped establish that CP violation arises through two different mechanisms. DONuT made the first direct sighting of the elusive tau neutrino in 2000, producing headlines around the world. In 2001, the NuTEV experiment caused excitement when its measurement of the mixing angle related to the breakdown of the electroweak symmetry complemented—but somewhat disagreed with—results from LEP, SLC and Tevatron collider experiments.

20 Tevatron

The Tevatron collider began operation in late 1985 with a handful of proton-antiproton collisions seen in the partially completed Collider Detector at Fermilab. The CDF experiment started in earnest in 1987, while the more junior DZero collaboration, which started from scratch in 1983, began operating its detector in 1992. It proved to be important for the field that there were two large general purpose experiments. We've learned much from the techniques invented by both collaborations, and sometimes the two groups have combined scientific results to make more progress than possible with one experiment alone.

Although CDF and DZero share their main goals, the true *modus vivendum* has been of sibling rivalry. This competition often brings out the best in both collaborations, as they try to wring every ounce of significance from the data.

My view of the collider's high points are of course colored by the rose tinted glasses worn by those of us who have labored at DZero and CDF, where the men are good looking, the women are strong, and the physics is all above average. Indeed, it is the people of the collaborations and the Accelerator Division—now Beams Division—who have made the Tevatron the success that it has been. The real hero is the Tevatron itself, whose collision energy of nearly 2 TeV and luminosity more than 10 times its design value made the discoveries possible.

Photo by Fred Ullrich

The DZero collaboration electronically submits the top quark discovery paper in 1995. A mile away, the CDF collaboration simultaneously sent their discovery submission.

Fermilab photos

Members of the FOCUS collaboration pose in front of their fixed-target experiment in 1996.

DZero and CDF have achieved results exceeding the hopes of almost everyone. An obvious highlight was the discovery of the top quark in 1995, and the measurement of its mass and its production rate. Assuming the Standard Model of particles and interactions, experiments at LEP and SLC had given an indication of its mass. Nevertheless, the extraordinarily large mass, almost 40 times the mass of the next heaviest bottom quark, was unexpected. About as heavy as a gold atom, the top quark mass is a striking indication of something new and fundamental.

The accomplishments of the collider experiments are much broader than just the top quark studies. CDF discovered the B_C meson (a bound state of bottom and anti-charm quarks), and provided early indications of CP violation in B meson decays. DZero made the first determination that W bosons and photons interacted with each other in accordance with the unified weak and electro-magnetic theory, inconsistent with models without electroweak unification. The measurement of the W boson mass by both experiments to a precision of 0.1% was a *tour de force* that constrains the Standard Model to this day and helps to pin down the Higgs boson mass.

The collider experiments have searched for telltales of new physics, both those predicted in speculative theories that extend the Standard Model, as well as wholly unexpected behavior. Though the lack of evidence for such new phenomena is disappointing, the experiments have significantly constrained the possibilities for the new physics that we are convinced must exist. Our measurements have set limits on new heavy partners to the W and Z bosons; heavy quarks; compounds formed by new heavy techniquarks; supersymmetric particles; magnetic monopoles; and extra dimensions besides the familiar three.

CDF and DZero have examined the strong force at higher and higher energies through measurements of the production of jets of particles resulting from violent collisions of quarks and gluons. Studies of jet production at lower energy and transverse momenta as well as the production of W and Z bosons have helped extend understanding of non-perturbative QCD. The list goes on, with results documented in over 350 papers and 375 Ph.D. theses from CDF and DZero alone. Two smaller collider experiments, E811 and MiniMax, measured proton-antiproton elastic scattering and the exotic production of low transverse momentum particles.

Much of the pleasure looking back at the first 20 years of the Tevatron comes from personal interactions. When DZero first started, we waited eagerly for the accelerator to deliver beams and to see the first collisions. The champagne was chilled and ready. Finally, on April 14, 1992 the Tevatron delivered and DZero observed. Alas, frivolity on the premises seemed not such a good idea as the DOE Tiger Team was in residence, turning the lab upside down. Hence we held the celebration in the DZero hall at eleven at night—believing that the zeal of the Tigers would be insufficient to catch us in our revelry.

The members of the collaborations form strong bonds not only through long hours of operating the experiment and bludgeoning the data into shape, but also through their strong personal interactions. One year, the motto of the DZero annual workshop banquet was "DZero goes to the movies." After-dinner speakers poked fun at collaboration members by pasting familiar faces onto movie character pictures. The leaders of the four French institutes became d'Artagnan and the Three Musketeers, whereas the upgrade leader and commissioning czar were depicted as Batman and Robin. One of my own proudest moments in DZero was being shown as Yoda from *Star Wars*.

It has been a great two decades. Congratulations to the Tevatron and all who made her a success.

Paul Grannis *is Distinguished Professor of Physics at the State University of New York at Stony Brook. He was spokesman of the DZero collaboration from inception in 1983 to 1993, and co-spokesman to 1996. He won the 2001 W.K.H. Panofsky Prize of the American Physical Society for his "distinguished leadership and vision in the conception, design, construction, and execution of the DZero experiment at the Fermilab Tevatron proton-antiproton collider."*

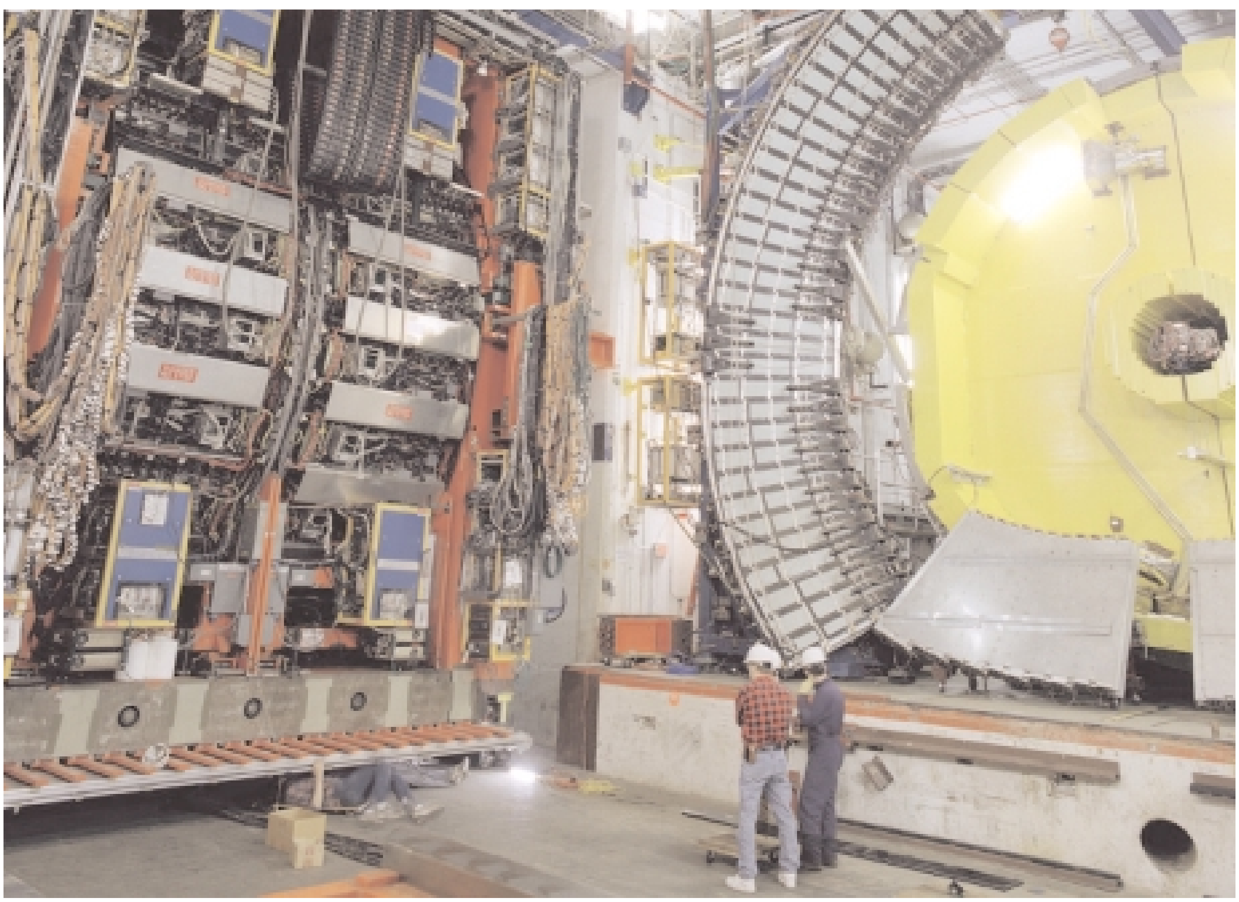


Photo by Reidar Hahn

The upgraded CDF detector rolls back into the collision hall in 2001.

Twenty Years of Physics and

by Elizabeth Clements

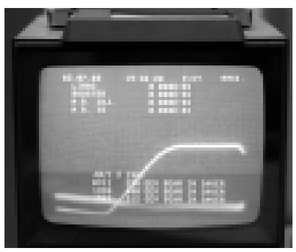
For 20 years the Tevatron has been the world's most powerful accelerator. Created by bright minds and strong hands, the award-winning design of the Tevatron has been the foundation of scientific and technological success. Many milestones highlight 20 years of achievements for the machine and the people who built and use it.

July 5, 1979 DOE authorization of the Tevatron project.

March 18, 1983 Installation of the last of 774 superconducting dipole magnets in the Tevatron.

May 29, 1983 All magnets cooled to below 5 Kelvin by the largest cryogenic cooling system in the world.

July 3, 1983 Tevatron achieves world-record proton beam energy of 512 GeV. On February 15, 1984, the record is raised to 800 GeV.



512 GeV computer screen

October 1, 1983 Fixed-target program begins with five experiments, initially with 400 GeV proton beam.

November 10, 1983 Fermilab wins four Industrial R&D Magazine "I-R 100" awards for the most significant technical products of the year, honoring technical aspects of the Tevatron and two physics experiments.

Bob Ferry, Fred Walters, Claus Rode, and Jay Theilacker toast the Tevatron helium transfer line, one of four Fermilab innovations that one an I-R100 award in 1983. Other award-winning Fermilab products: a precision electric-current sensor, the ECL-CAMAC ultra-high speed computer, a slip-ring stepping motor.

April 1, 1984 Start of first physics run with 800 GeV proton beam.

April 28, 1984 Dedication of the Tevatron in the presence of DOE Deputy Secretary Danny Boggs, Senator Charles H. Percy, Illinois Governor James R. Thompson and other dignitaries.

October 13, 1985 The CDF detector observes the first proton-antiproton collisions at 1.6 TeV.

July 24, 1986 Helen Edwards wins the E.O. Lawrence Award for her leadership in the construction and commissioning of the Tevatron at Fermilab.

October 21, 1986 Acceleration of protons to a new record energy of 900 GeV. CDF records the first 1.8 TeV collisions on November 30, 1986.

May 1986 Tevatron named one of the Top Ten Engineering Achievements of the last 100 years by the Illinois Society of Professional Engineers.

March 26, 1987 First "new world" W boson detected at CDF.

June 7, 1987 Mike Syphers graduates as the first student of Fermilab's Accelerator Ph.D. program.

June 20, 1988 First collider run begins with CDF taking data.

October 18, 1989 President George Bush presents the 1989 National Medal of Technology to four Tevatron scientists.

Helen T. Edwards, Richard A. Lundy, J. Richie Orr, and Alvin V. Tollestrup received the 1989 National Medal of Technology for their work in the design construction, and initial operation of Fermilab's Tevatron accelerator.

April 14, 1992 The new DZero detector observes first collisions.

August 31, 1992 Run I begins, the first Tevatron run with two collider detectors.

Technology Achievements

September 27, 1993 Tevatron's cryogenic cooling system is named International Historic Mechanical Engineering Landmark by the American Society of Mechanical Engineers.

The 1993 ASME award recognizes the innovative engineering involved in the design and fabrication of the Tevatron cooling system and a decade of reliable operation.

May 17, 1993 Fermilab's Thomas Collins wins the Particle Accelerator Science and Technology Award for his invention of long, straight sections for synchrotron and storage rings and his design of Fermilab's accelerator lattices.

April 26, 1994 CDF announces the first direct evidence for the top quark.

March 2, 1995 CDF and DZero announce the discovery of the top quark. Scientists worldwide sought the top quark since the discovery of the bottom quark at Fermilab in 1977.

A press conference on the 1995 discovery of the top quark drew reporters from across the world. Film crews surrounded Fermilab Director John Peoples as he gave an interview.

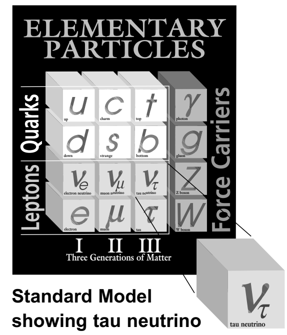
May 10, 1995 The Tevatron achieves a peak luminosity of 25E30 cm^{-2}sec^{-1}, the highest mark of Run I.

February 20, 1996 Run I ends with a total integrated luminosity of 180 inverse picobarns.

September 15, 1997 The historic 400-GeV Main Ring is shut down for dismantling. (In Run II, the Tevatron receives protons from the new Main Injector accelerator.)

February 5, 1999 CDF scientists report evidence of CP violation in neutral B mesons—a phenomenon that could help explain why matter reigns in our universe while antimatter has virtually disappeared.

January 31, 2000 After more than 40 experiments, Fermilab concludes its Tevatron fixed-target program. It led to more than 300 scientific publications and about 400 Ph.D. degrees. Future fixed-target experiments will receive beam from the Booster and the Main Injector.



Standard Model showing tau neutrino

July 21, 2000 The DONUT collaboration, which recorded data with a Tevatron fixed-target experiment in 1997, announces the first direct evidence for the tau neutrino.

August 5, 2000 Tevatron produces 980 GeV beam energy, a new world record.

March 1, 2001 Run II begins with proton-antiproton collisions close to 2 TeV.

May 1, 2000 DZero scientist Paul Grannis, SUNY Stony Brook, receives the prestigious W.K.H. Panofsky Prize for his leadership on the DZero experiment.

July 26, 2002 Run II sets peak luminosity record of 26E30 cm^{-2}sec^{-1}, improving the Run I mark.

March 10, 2003 Run II surpasses the total integrated luminosity of Run I, exceeding 180 inverse picobarns.

March 19, 2003 The CDF collaboration submits its first Run II result for publication.

First Run II paper.

August 10, 2003 The Tevatron raises the peak luminosity record to 49E30 cm^{-2}sec^{-1}, twice the Run I record.

August 31, 2003 Since the beginning of Run II the Tevatron has produced 334 inverse picobarns—and counting.

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1983 The Year the

20 Tevatron

by Kurt Riesselmann

It was the weekend before the Fourth of July. While the nation was preparing for another national holiday, accelerator experts at Fermilab worked around the clock to push the Energy Doubler—now known as the Tevatron—to new limits. The weather did not cooperate. A lightning bolt struck a Tevatron service building at 3 a.m., damaging enough sensitive electronics to cause six hours of diagnosis and repair. More lightning-induced trips took place the next morning. The following night, torrential rains flooded the site, and water found its way into some electronics racks.

Fermilab's scientists and technicians persisted. On Sunday morning, July 3, at 2 a.m., beam operators made the first serious attempt to accelerate beam in the Tevatron. In a second attempt on Sunday afternoon, at 3:37 p.m., they succeeded, achieving record beam energy of 512 GeV. "News of this historic achievement spread rapidly—by telephone and telex to all quarters of the world," the late physicist Thornton Murphy wrote in Ferminews in July of 1983. "The Control Room rapidly filled with off-shift workers and other well-wishers as the champagne was broken out."

When installed, the new Tevatron accelerator fit tightly underneath the existing Main Ring accelerator. In 1997, the older accelerator was dismantled and its magnets reused in the Main Injector accelerator.

The achievement paved the way to many great things: a spectacular lab-wide party that saw Director Leon Lederman dancing with Big Bird, an Open House for Fermilab's neighbors, and—finally—the start-up of the Tevatron fixed-target program on October 1 (with only 26 hours of beam delivered in that first month). A few months later the Tevatron pushed the world record to 800 GeV, doubling the energy of its predecessor, the Main Ring accelerator.

All along, the lab worked toward its most ambitious goal: the operation of the Tevatron as a proton-antiproton collider. From the construction of quadrupole magnets to the groundbreaking for the Antiproton Source to work on the first collider detector, the lab made progress.

"What we are witnessing is the gradual restoration of Fermilab as an operating laboratory," Lederman conveyed in the 1983 annual report. "There is a revival of spirit that comes from doing physics again —a new-old sweetness of mood. Even the complaints are a joy."

Twenty years later, the complaints are forgotten. But we will always remember how the Tevatron came to life.

Tevatron Came to Life

A large crowd watched as technicians installed the last Tevatron magnet on March 18, 1983.

Members of the E715 collaboration, the first experiment to use the Tevatron on Oct. 1, 1983, posing with their detector. E715 examined how hyperons—particles containing a strange quark—are produced and how they decay.

Helen Edwards signs the placard that proclaims the installation of the last Tevatron magnet.

At the 512 GeV party on July 8, 1983, founding director Robert Wilson celebrated the Tevatron, his vision turned reality.

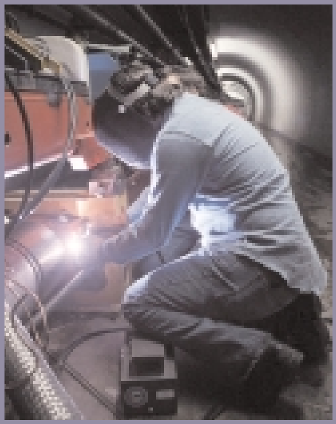
Leon Lederman and Linda Klamp celebrate the 512 GeV record energy achieved in 1983.

To handle the amount of expected data, Fermilab installed new computers on the seventh floor of Wilson Hall in Fall of 1983.

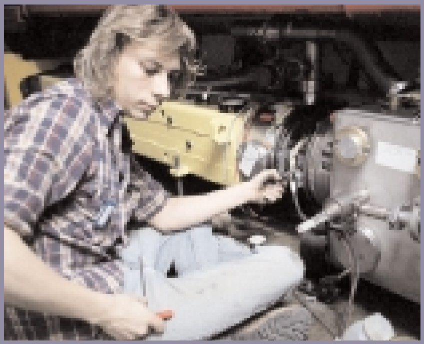
1983

Leon Lederman addresses lab employees at a lab-wide celebration of the 512 GeV record. Fermilab employed almost 2,000 people in 1983.

Technicians with the first quadrupole magnet for the Tevatron collider program. Collider operations began in 1985.



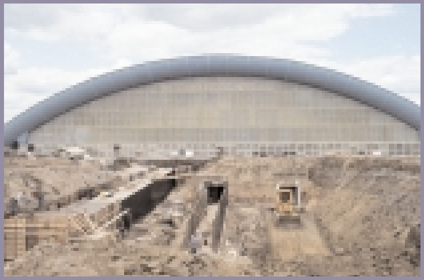
A welder works on the Tevatron.



An electrician installs power for the Tevatron.

Fixed-target experiment E665 featured the large Chicago cyclotron magnet. The New Muon Building, which houses the magnet to this day, was built around the magnet.

At an Open House on September 18, 1983, friends and neighbors learned more about Fermilab's new accelerator. Here visitors are talking to employees at the Main Control Room.



Construction of the beam line to the Meson Laboratory, where some of the first Tevatron fixed-target experiments took place in Fall of 1983.

20 Tevatron

Guided by Rich Orr (right), Secretary of Energy Donald Hodel takes a tour of the Tevatron tunnel in February of 1983.

Some things never change: Annual Users Meeting at Fermilab in 1983.

Crazy times in 1983: Leon Lederman dancing with Big Bird at the 512 GeV party.

Did the Tevatron get a blessing? Cardinal Joseph Bernardin (right, next to Leon Lederman) visited the lab in April 1983.

A 1983 computer simulation of proton-antiproton collision in the CDF detector.

An employee installs a photo multiplier tube in a calorimeter unit for the CDF detector.

The Main Control Room on Sunday, July 3, at 3:37 p.m. as the Tevatron accelerated protons to 512 GeV, a new world record for accelerators.

In March of 1983, technicians completed the last collared dipole coil for the Tevatron.

Superconducting Magnets

From Wilson's vision to a hospital near you

by Matt Hutson

Fermilab Photo

To produce superconducting wire, technicians bundle 2,100 niobium-titanium alloy filaments into a single billet, which gets rolled and stretched into a thin wire. The photo in the background shows an enlargement of wires in a superconducting cable.

ON THE WEB:

Tevatron Magnets:
www-bd.fnal.gov/public/tevatron.html

LHC Magnets:
www-td.fnal.gov/projects/lhc.html

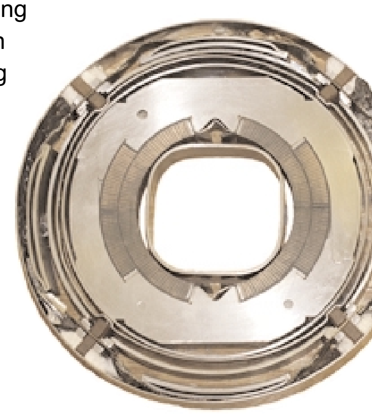
Accelerators Science in Medicine:
www.fnal.gov/pub/pulse/

When you cool a piece of metal below a critical temperature, something magical happens. The atoms begin passing along electrons with zero resistance. People in the know refer to this rare state as “superconductivity.”

When Robert Wilson set out to build the world’s most powerful particle accelerator, he envisioned using superconducting magnets for guiding and focusing the beam of protons. Despite the superior power and efficiency of these magnets, no one had any idea how to build a whole accelerator out of them. But Wilson left room in the tunnel under the normal-conducting magnets of the Main Ring for a future upgrade, and as soon as the Main Ring began operating in 1972 he launched a superconductor R&D program.

The new ring didn’t earn the name Tevatron until after construction, as it approached one trillion electron volts (1 TeV) per beam. Originally it went by two names: the Energy Doubler and the Energy Saver. The new accelerator would produce twice the beam energy of the old one, and because the magnets lacked electrical resistance they wouldn’t need a constant source of current to stay magnetized. Despite the need for cooling, Fermilab’s electrical bill would decrease by a predicted $5 million a year.

The idea of constructing a superconducting cyclotron gathered many critics. The plan required 774 dipole magnets (for steering the beam) and 216 quadrupole magnets (for focusing), plus a stable of spares, each about 20 feet long. Alvin Tollestrup, a key player in the magnet development, recalls giving a talk on the subject at CERN, where he encountered “a big room with these guys sitting up there laughing… they thought we were nuts.”



Dipole magnet cross section

Production of superconducting cable presented the first big challenge. Each magnet has either two or four full-length coils of Rutherford cable. Each cable has 23 strands of wire twisted together. And each strand, only 27 thousandths of an inch in diameter, has 2100 niobium-titanium alloy filaments running through a matrix of copper. Finding the right materials, the right heat treatments, the right configuration of elements, and the right cabling method proved significant hurdles. And Fermilab needed the stuff in bulk. (Bulk as in about a quarter of a trillion feet of filament.)

> **"Every program in superconductivity that there is today owes itself in some measure to the fact that Fermilab built the Tevatron and it worked."**
>
> **—Robert Marsh, former CEO of Oregon-based Teledyne Wah Chang, world's largest supplier of superconducting alloys.**

Running current through the coil would produce more than a ton of outward force per linear inch. But to prevent friction and avoid losing superconductivity, the coils needed to remain motionless. The solution: epoxy-covered steel collars, custom-made to an accuracy of .001 inch, bound around the coils with a huge hydraulic press. Engineering won out.

The lab's success may rest on one of Wilson's most innovative ideas: the magnet factory. Other labs concentrated all their efforts on building one good magnet. Some magnet builders succeeded but couldn't reproduce their success with a second magnet. Wilson's teams built dozens of miniature test magnets, each only one or five feet long. The lab could build, test, and redesign these mini-magnets in only a few weeks. The idea was to keep churning out test magnets until one worked. When successful, the lab had two things: a good magnet, and an assembly line for producing good magnets.

Success with the Doubler laid the groundwork for future accelerators around the world. Two scientists from DESY who came to help with the Tevatron's magnets took their experience back with them to work on HERA, the hadron-electron ring accelerator in Hamburg, Germany. The ill-fated Superconducting Super Collider in Texas also would have used magnets designed and built at Fermilab. In 1994, Fermilab began R&D for the construction of CERN's Large Hadron Collider (LHC). The lab will produce nine of the collider's 18 six-ton quadrupole magnets, and put all 18 into cryostats. Along with new people and equipment, the lab has marshaled the facilities, tooling, and experience gained from the Tevatron and the SSC to forge this new effort.

Although commissioning of the LHC remains four years away, Fermilab's Technical Division has been working since 1998 on a research program to produce accelerator-quality magnets capable of at least 11 Tesla. (For comparison, the Main Ring was 1.8T, the Tevatron is 4.2T, and the LHC will be 8.4T.) The High Field Magnet Program (HFM) includes a team led by Emanuela Barzi exploring new superconducting materials. The new strands—a mixture of copper, niobium, and tin—can produce fields as high as 16T. The ongoing R&D now guides the LHC Accelerator Research Program (LARP), aimed at more powerful magnets set to replace those in the LHC 12 years from now.

Pushing the limits of material science has benefited more than particle physics. The Tevatron paved the way for today's largest superconductor application: magnetic resonance imaging (MRI). Engineers calculated that Fermilab at one point had purchased 95% of the niobium-titanium the world had ever produced. Robert Marsh, the head of a major alloy supplier, once said that "every program in superconductivity that there is today owes itself in some measure to the fact that Fermilab built the Tevatron and it worked." The market for superconductors currently stands around $3.5 billion a year. As ever, Wilson was on the frontier of something big.

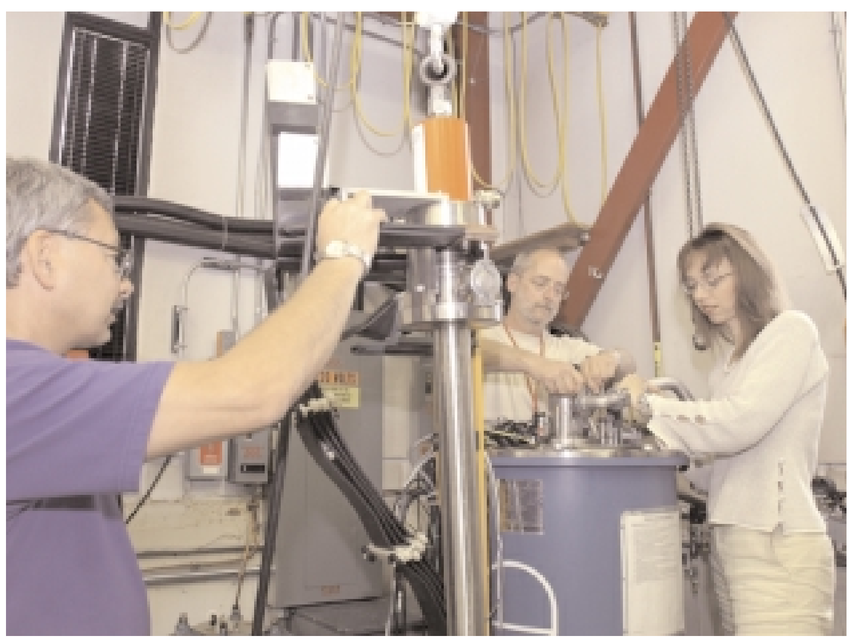


Photo by Fred Ullrich

Superconductor R&D scientist Emanuela Barzi (right) with lab technicians Tom Wokas (left) and Tom Van Raes testing niobium-tin samples in a cryostat.

20 Tevatron

Cold, Hard Fact: No Tevatron Without CRYOGENIC SYSTEM

by Mike Perricone

Fermilab Photo

Fermilab's Central Helium Liquefier (CHL)

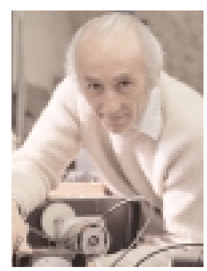
It all comes down to this:

To supercool more than 1,000 superconducting magnets in a four-mile ring, achieving the zero electrical resistance for the 4,400-ampere current that makes the Tevatron uniquely the Tevatron, the massive and intricate cryogenic system at Fermilab must deliver a peak rate of 24 kW at 4.5 Kelvin (-269.5°C, about -450°F) through a circuit of 15 miles of vacuum-jacketed pipeline. Thanks to superconductivity, and to that cryogenic delivery system, power consumption for the Tevatron is just one-third what it would be at normal temperatures.

If that sounds like a landmark achievement, it is.

The world's largest system of its kind when completed in 1983, the Fermilab cryogenic system was named an International Historic Mechanical Engineering Landmark in 1993 by the American Society of Mechanical Engineers. Fermilab physicists Bill Fowler and Ron Walker, and engineer Claus Rode, were in charge of constructing the cryogenic cooling system, a hybrid design consisting of a large central helium liquefier and 24 satellite refrigerators. The lab organized a sitewide effort, with staffers from many departments, to meet the schedule for construction and commissioning.

On May 29, 1983 the entire Tevatron was cooled down and operated for the first time. The cryo system passed another major test on July 3, 1983, with the Tevatron accelerating a proton beam to 512 GeV—the world's highest energy for a particle beam, doubling the energy of the original Main Ring accelerator, thanks to the near-absolute zero temperatures enabling the phenomenon of superconductivity.



Hans Kautzky

If everyone involved felt equal parts elation and relief that the project worked as well as it did, a special category was reserved for one critical piece of the apparatus developed at the lab to contend with the fact that when liquid helium warms up to a gaseous state, it occupies 700 times the volume of its liquid state. And it expands very quickly. When a magnet experiences heat from electrical resistance and quenches, or rises above superconducting temperatures, and the whole system begins to warm up, a cubic liter of liquid helium becomes 700 cubic liters of gaseous helium within a quarter of a second.

All that gas has to go somewhere, in a big hurry, and in this case relief is spelled K-A-U-T-Z-K-Y.

The quick-acting, self-sealing cryogenic relief valve that bears his name was developed by Fermilab engineer Hans Kautzky, now retired. More than 1,500 Kautzky valves around the Tevatron ring allow the system to "blow off steam" in the event of a quench. The poppet, the key element in the Kautzky valve, is able to open quickly and then reseat itself because it operates counter to the incoming flow. The relieving pressure is set by control gas from a bottle

ON THE WEB:

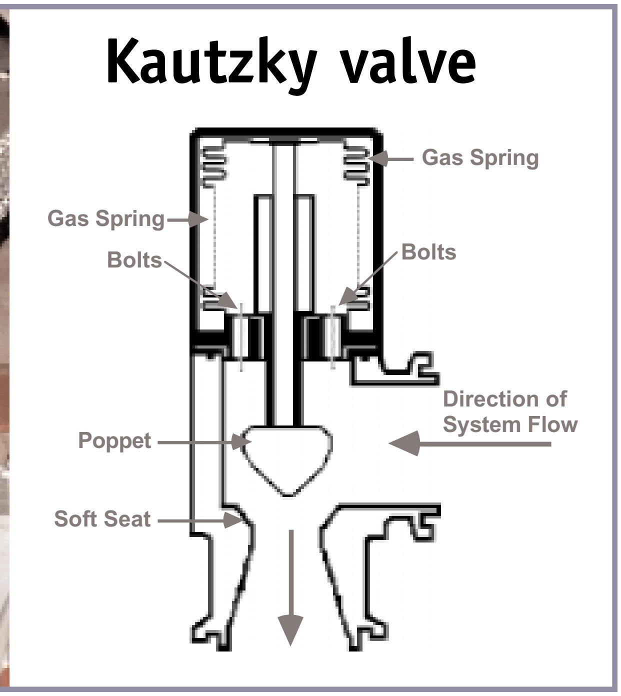
Beams Division Cryogenic Department:

www-bdcryo.fnal.gov

American Society of Mechanical Engineers: The Fermilab Tevatron Cryogenic Cooling System:

www.asme.org/history/brochures/h169a.pdf

Fermilab Photo



Jay Theilacker (right) and Ken Olesen change a Kautzky valve in 1982, the early days of the cryo system. Says Theilacker: “We recognized early that safety was an important issue while changing a Kautzky valve. Three people are required to change a valve. Two actually change the valve and a third is available to hand tools and equipment to them. As I remove the valve, Ken is preparing to insert a plunger to stop the flow until I can get a new valve ready. During this change, the o-ring stuck to the flange on the magnet instead of staying on the valve I removed. This forced Ken to swipe it off with his glove prior to inserting the plunger. Note the face shields, gloves, long pants and shirts required. Since then, we have found long cryogenic gloves that go nearly to the elbow to avoid the exposed skin you see on my right wrist.”

of helium in the service building. When the pressure in the magnets gets above the set point, the poppet of the valve begins to lift and quickly sets up a large differential pressure across the bellows separating the control and magnet pressures. This difference quickly snaps the valve fully open. As the pressure drops, the gas spring will close the valve. (see diagram)

Jay Theilacker remembers many cloud-filled adventures in changing Kautzky valves when operators were still finding out how to make the system run smoothly.

“We had to change quite a few in the early days, due to screws that hold the superconductor in the ends of the dipoles coming loose and getting caught in the valve,” said Theilacker, now head of Fermilab’s Cryogenic Department. “We also had many that had welding rod stuck in them. The welding rod was used during construction of the component to hold open a flapper-type check valve in order to leak-check during magnet production. Many were left in the component and eventually got stuck in the Kautzky valve after a quench.”

In changing those valves, Theilacker added, “you can see that quite an interesting plume comes out.”

In its 20 years of operation, Fermilab’s landmark cryo system has undergone several upgrades to increase its capacity and efficiency. But thanks to early innovations like the Kautzky valve, the system has kept the Tevatron cool and kept the physics flowing.

FN EE RW MS I

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Office of Science / U.S. Department of Energy / Managed by Universities Research Association, Inc.

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

Design and Illustration:
Performance Graphics

Photography:
Fermilab’s Visual Media Services

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

***FERMINEWS* has changed to a monthly schedule. The deadline for the December 2003 issue is Tuesday, November 18, 2003.**
Please send story ideas to:
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Fermilab is a national laboratory funded by the Office of Science of the U.S. Department of Energy, operated by Universities Research Association, Inc.

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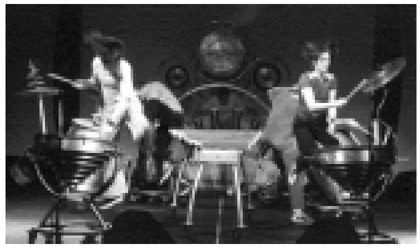
To purchase tickets for Arts and Lecture Series events, or for further information or telephone reservations, **call 630-840-ARTS** weekdays between 9 a.m. and 4 p.m. Phone reservations are held for five working days, but will be released for sale if not paid for within that time. Will-Call tickets may be picked up, or available tickets purchased, at the lobby box office on the night of the performance beginning at 7 p.m. When coming to this event, only the Pine Street entrance to Fermilab will be open. *For more information, check out our web page at* **www.fnal.gov/culture.**

Scrap Arts Music

November 15, 2003

Tickets $22
($11 ages 18 and under)

"This is one fantastic visual and aural display of percussive precision full of energetic gymnastics and vibrant vitality. Original music expertly played and choreographed into a remarkable show."
- The Belfast Telegraph



CALENDAR

Lab-Wide Party

November 21, 2003

Save the date: lab-wide party on Friday, November 21, from 3:30 to 6:30 p.m. in the Wilson Hall atrium.

Details will be announced in the next few weeks.

MILESTONES

AWARDED

- Fermilab Employee Performance Recognition Awards to Brad Trygar, Deborah Griffin, Wei Gao, Cheryl McKenna, and Robert Willford for their roles in the in the lab's biggest accounting makeover, launching Oracle Project Accounting.
- Fermilab Employee Performance Recognition Award to Cathy Newman-Holmes for coordinating the Lepton-Photon Symposium in August 2003.
- Fermilab Employee Performance Recognition Award to Ron Moore and Keith Gollwitzer for their work as Run Coordinators; and to Jeff Spalding for preparing and implementing the Run II plan.
- Fermilab Employee Performance Recognition Award to Duane Plant, for his role in the reclamation of water from the NuMI underground enclosures for use in laboratory operations.
- The first 35-year service awards in lab history to Lincoln Read (ID 5), Barb Kristen (ID 59), and Carolyn Hines (ID 47).

NAMED

- As AAAS Fellows: Fermilab theoretical physicists Estia Eichten ("for landmark contributions to theoretical physics, including quarkonium bound states and heavy-quark symmetry, dynamical electroweak symmetry breaking, lattice QCD, and supercollider physics"), and Joe Lykken ("for imaginative and influential explorations of supersymmetry, string field theory, and the physics of extra dimensions and for inspiring others through teaching and public lectures"). AAAS named 348 Fellows this year.

Chez Léon MENU

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

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

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

Lunch
Wednesday, November 5

Pork Loin
with Apple Salsa
Potato and Celery Root Mash
Mango Banana Cake

Dinner
Thursday, November 6

Bean and Swiss Chard Soup
Sake Steamed Halibut
with Dill Carrots
Salad of Beets and Onions
Ginger Flan

Lunch
Wednesday, November 12

Roasted Vegetable
and Goat Cheese Calzone
Caesar Salad
Chocolate Semi Freddo

Dinner
Thursday, November 13

French Onion Soup
Filet Mignon Au Poivre
with Cognac Sauce
Potato Dauphinoise
Vegetable of the Season
Chocolate Souffle with Cream Anglais

Lunch
Wednesday, November 19

Trout
Lemon Scented Rice
Vegetable of the Season
Apple Walnut Cake

Dinner
Thursday, November 20

Coquilles Saint-Jacques
Veal Saltimbocca
Spinach Fettuccine
Strawberry Shortcakes

Lunch
Wednesday, November 26

Cheese Fondue
Marinated Vegetable Salad
Poached pears
with Chocolate Sauce

Dinner
Thursday, November 27

CLOSED

THANKSGIVING DAY

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

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