Extra data bolster top quark discovery

The top quark's true identity is beginning to emerge from the debris of trillions of high-energy collisions between protons and their antimatter counterparts.

Last year, physicists at the Fermi National Accelerator Laboratory (Fermilab) in Batavia, Ill., presented the first direct experimental evidence for the existence of the long-sought top quark (SN: 4/30/94, p.276). But significant uncertainties in the limited data available rendered the results suspect.

Now, after acquiring and sifting through three times as much data, Fermilab researchers are confident that they have indeed discovered the top quark. Moreover, teams using two different detectors have observed traces of this elusive subatomic particle. A year ago, only the group using the Collider Detector at Fermilab (CDF) claimed any sightings.

At that time, researchers at the rival DZero detector "just did not have enough events to make a statement about the top quark's existence, but now, with a larger data sample, the signal is clear," says Paul D. Grannis of the State University of New York at Stony Brook, a DZero team member.

Representatives of the CDF and DZero teams reported their findings at a seminar held last week at Fermilab.

According to the standard model of particle physics, quarks come in six varieties. Two kinds of quarks — known as up and down quarks — combine to create the protons and neutrons of everyday matter. Three other types of quarks — strange, charm, and bottom — have been found using particle accelerators. The newly discovered top quark completes the family.

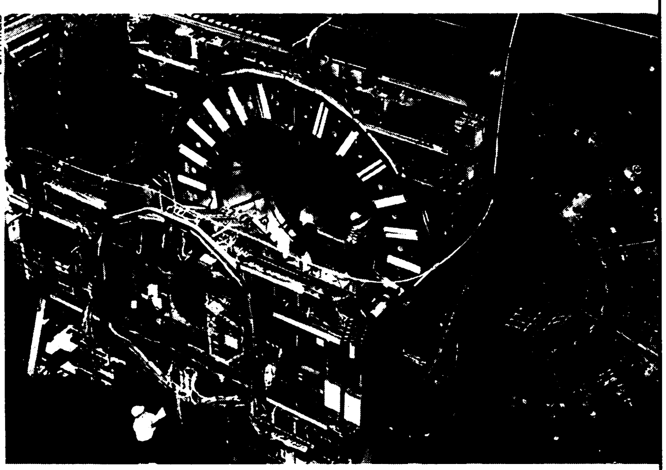
Created as quark-antiquark pairs in collisions between protons and antiprotons moving at nearly the speed of light, top quarks disintegrate almost immediately to create characteristic showers of other particles that physicists can then detect. However, because decays of other subatomic particles can mimic those postulated for the top quark, researchers must take care to distinguish these "background" events from genuine top quark decays.

Out of trillions of collisions, the CDF team identified about 40 events as top quark candidates, significantly more than the 12 events expected as background. From these data, the physicists calculated that the top quark has a mass (expressed in energy units) of 176 billion electronvolts (GeV), with an uncertainty of 13 GeV.

"The new mass estimate closely matched our previous measurement," says Paul Tipton of the University of Rochester and a member of the CDF group. "This was very reassuring and made us believe the result that much more."

The DZero group has found about 17 candidate events, leading to a mass estimate for the top quark of 199 GeV, with an uncertainty of 30 GeV. "There's a good overlap between the measurements," Tipton says.

"The detectors are vastly different, and what you record is very different, but the physics of producing the particles and what those particles do in the detectors is the same," adds DZero team member Andrew R. Baden of the University of Maryland in College Park. "I think it's pretty clear now that [both detectors] are looking at the same phenomenon."



Fermilab

The massive Collider Detector at Fermilab (CDF) dwarfs its human operators.

The two teams plan to continue collecting data until the end of the year. "By then, we'll have twice the data we have now," Baden says.

Much effort will go into reducing the uncertainty in the top quark mass. As the number of candidate events increases, researchers will also begin to study other characteristics of the top quark.

"We have this new particle, and we're the only people in the world who have what is, in effect, a new laboratory," Tipton says. "There are possibilities for observing new physics in both how the top is produced and how it decays."

— I. Peterson

Seizing two genes for fast heartbeat

Researchers say they have fingered two genes underlying a lethal heart rhythm abnormality that can strike young, healthy people without warning. The finding, reported this week, may pave the way for early diagnosis and treatment of individuals who have inherited this condition, which occurs in about 1 in 10,000 individuals. More than 300,000 people in the United States die suddenly each year; in many cases the underlying cause may be an aberrant cardiac rhythm.

The disorder is called long QT syndrome for the abnormally long wave it may produce on an electrocardiogram, a tracing of the electrical activity of the heart. The first indication of trouble may surface suddenly, in the form of an episode of rapid, irregular heartbeat. That ineffective heart rhythm can lead to blackout spells and even death.

Mark T. Keating of the Howard Hughes Medical Institute at the University of Utah Health Sciences Center in Salt Lake City and his colleagues had previously reported that certain regions of chromosomes 7, 3, and 11 appear to contain genes responsible for this deadly syndrome.

They also knew of the discovery by another research team of a gene on chromosome 7 believed to contain the blueprint for an ion channel, a protein embedded in the surface of cells. Certain ion channels keep the heart beating rhythmically. Keating's group speculated that this gene, called HERG, plays a role in long QT syndrome.

To test that theory, they first demonstrated that HERG lies within the expected region of chromosome 7. "That's when it became a really exciting candidate," Keating says, although he ruefully acknowledges that other promising genes have not panned out.

Further research suggested that while HERG's protein product turns up on other cells of the body, it is usually found on the surface of heart cells.

Finally, the researchers identified HERG mutations in six families with long QT syndrome. They describe their results in the March 10 CELL.

The researchers believe that a flaw in HERG leads to a faulty potassium ion channel. Normally, this protein acts as a switch that turns contracting heart cells off. Without a functional potassium channel, these cells lack one of several "brakes" that keep the heartbeat under control. If another factor, such as stress or medication, knocks out the remaining brakes, the heart begins to race too fast to pump blood effectively.

"The engine of the heart goes galloping out of control," Keating says.

In a separate March 10 CELL report, Keating's team showed that a different gene, this one on chromosome 3, can also underlie long QT syndrome. This gene, called SCN5A, encodes a sodium ion channel, another regulatory protein on the surface of heart cells.

However, this gene's protein product appears to work as an accelerator. A mutant sodium channel thus gives heart cells an accelerator that is stuck in the "on" position, Keating says. This defect can also predispose people to develop a heart rhythm that can cause death within seconds.

The researchers describe a small mutation in SCN5A that appears in two families with this disorder.

Taken together, the flaws in HERG and SCN5A account for about 75 percent of all cases of long QT syndrome, the researchers believe.

Still other genes probably contribute to this disorder. Keating's group continues to search chromosome 11 for another such gene — to no avail, so far.

The present discovery bodes well for people who know this disorder runs in their family, comments Robert Roberts at the Baylor College of Medicine in Houston. Many people with one of these genes go undiagnosed because they have normal-looking cardiograms. Researchers can now test the blood of individuals who have a family history of sudden death or fainting spells to see if they carry either of these mutant genes, says Roberts, a specialist in the molecular biology of the cardiovascular system. If so, doctors can start targeted treatment to counter the genetic flaw.

Hopefully, Roberts says, such therapy will prevent episodes of a runaway heart — and death. — *K. Fackelmann*

Enzyme helps microorganism thrive in heat

Beneath southern Italy's sparkling Mediterranean waters dwell some bizarre life-forms. Beside thermal seafloor vents, a primitive microorganism, the bacteria-like archaeon, basks amid hot springs. Percolating up from Earth's interior, hot, sulfurous water spews forth from seafloor cracks, providing a rich environment for these organisms.

These tiny creatures use sulfur the way we use oxygen and thrive in tremendous heat.

Among them one finds *Pyrococcus furiosus,* which enjoys temperatures around 100°C. Since discovering them, scientists have puzzled over how the microorganisms can stand the heat. What special proteins or enzymes enable them to thrive in this hostile environment? And what keeps their key biological molecules from collapsing or breaking up at temperatures that would destroy those of conventional bacteria?

Delving into this question, Michael K. Chan, a chemist at the California Institute of Technology in Pasadena, and his colleagues report their determination of the structure of one of the bacterium's unusual enzymes, aldehyde ferredoxin oxidoreductase (AOR). Playing a fundamental role in the transfer of energy within the speck-sized organism, the enzyme helps it to flourish at extreme temperatures.

Using X-ray crystallography, the researchers found that the protein consists of two big pieces joined together, each containing a cluster of iron and sulfur atoms. Each piece also has a region containing tungsten and molybdenum, the team reports in the March 10 SCIENCE.

"Since most organisms can't tolerate this kind of heat, we're interested in how life can exist at such high temperatures, as well as the problem of how proteins remain stable and function in such heat," says coauthor Douglas C. Rees, a Caltech chemist. "We also want to know exactly what role tungsten and molybdenum play in this protein. It's not yet clear why they're there or exactly how they're used."

The Caltech team has also observed some unusual features of the AOR enzyme. Compared to other proteins, it has relatively little exposed surface area and an abundance of ions and atoms buried in its core. In addition, the enzyme's tungsten and molybdenum portions appear to help the organism use carbon, nitrogen, and sulfur more efficiently than it otherwise could.

Rees/SCIENCE

The AOR protein.

"By analyzing many of these proteins, we hope to find why they're stable at high temperatures," says Rees. "This could be useful for engineering other proteins and have a technological impact." — *R. Lipkin*

Atmospheric moisture: A warming sign?

The stratosphere at midlatitudes in the Northern Hemisphere has grown wetter over the last 14 years, report scientists at the National Oceanic and Atmospheric Administration (NOAA) in Boulder, Colo. They argue that the change may result in part from global warming.

NOAA researchers Samuel J. Oltmans and David J. Hofmann describe in the March 9 NATURE their measurements of water vapor content in the skies above Boulder. Their findings add to "concerns about the buildup of greenhouse gases and their effects on atmospheric chemistry, as well as climate," they say.

Atmospheric researchers believe that additional water vapor in the normally very dry stratosphere can aggravate destruction of the ozone layer and amplify global warming by trapping heat.

Every month, NOAA scientists at Boulder launch balloons carrying instruments to heights of 14 to 26 kilometers to measure water vapor in the lower stratosphere. Between 1981 and 1994, their data show a statistically significant increase in moisture. At an altitude of 18 kilometers, water vapor content climbed 8.4 percent per decade. At higher altitudes, it increased more slowly.

Although they have made measurements in only one spot, Oltmans and Hofmann believe their data are representative of Northern Hemisphere midlatitudes because water vapor concentrations do not vary as much in the stratosphere as they do in the lower atmosphere. Measurements made by NASA's SAGE II satellite support that conclusion, showing that the seasonal rise and fall of water vapor concentrations over Boulder match those at similar latitudes around the world.

Much of the additional water vapor in the stratosphere derives from methane molecules that filter up and react with oxygen to form water vapor, suggest Oltmans and Hofmann. Atmospheric methane has risen markedly in recent decades, partly because of human activities.

But methane alone cannot explain all the extra water vapor, especially at altitudes of less than 20 kilometers, say Oltmans and Hofmann. They suggest that some of the water vapor comes from increasing moisture in the lower atmosphere due to global warming. Theory predicts that warming of Earth's surface should increase evaporation from the oceans and make the atmosphere wetter.

Chemist Donald R. Blake of the University of California, Irvine, agrees that methane cannot account for the entire measured increase in stratospheric water vapor. Yet he notes that the global warming explanation remains speculation. Whatever the source, increasing moisture in the stratosphere can harm the ozone layer by stimulating the growth of polar clouds, which help pollutants destroy ozone.— *R. Monastersky*