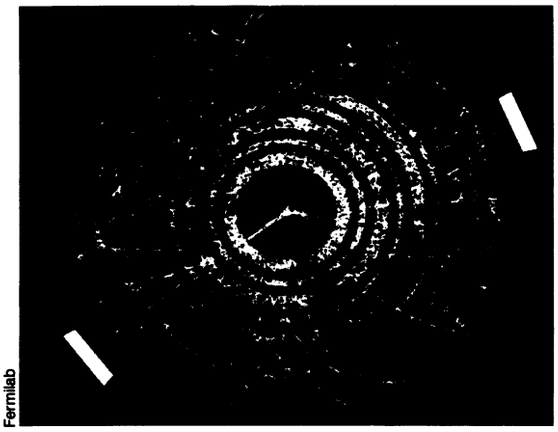
At Last, Evidence of the Top Quark

There was no eureka moment, no sudden revelation. Just the slow, painstaking accumulation of data from the debris of trillions of high-energy collisions between protons and their antimatter counterparts. In the end, the evidence favoring the existence of the long-sought top quark proved strong enough to warrant an announcement.

This week, physicists at the Fermi National Accelerator Laboratory (Fermilab) in Batavia, Ill., presented the first direct experimental evidence for the top quark. "Until now, there was not even a hint of top," says William C. Carithers of the Lawrence Berkeley (Calif.) Laboratory, speaking for the team of about 440 physicists using the Collider Detector at Fermilab (CDF). "Now, we're starting to see a hint that it's really there."



Fermilab

Computer-generated view shows curved particle tracks emerging from the center of a proton-antiproton collision. Tracks could represent products resulting from the decay of a top quark.

Quarks come in a variety of flavors. 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 in particle accelerators, and at least one of these types may exist at the center of extremely dense, massive stars.

For a variety of reasons, theorists have long believed that a sixth quark, much more massive than the others, ought to exist to complete the quark family of subatomic particles. With the 1977 discovery at Fermilab of the bottom quark, the search was on for the top quark.

Now, researchers using Fermilab's powerful Tevatron accelerator may have glimpsed the top. Created as pairs of top quarks and antiquarks in collisions between protons and antiprotons moving at nearly the speed of light, these massive particles disintegrate almost immediately in ways that create a shower of other particles that can then be detected.

The team spent nearly a year sifting through 1 trillion collisions to find 7 million events showing interesting particle interactions. Of these, 20,000 involved particles known as W bosons — one of the types of particles into which the top can decay. The final selection produced 12 events, representing three ways in which top quarks decay into other particles.

Because various subatomic particles can decay in ways that mimic those of the top quark, researchers have to be careful to distinguish these "background" decays from top quark decays. "We can't rule out the possibility that what we're seeing is a rare fluctuation in the background," Carithers says. But "we estimate that chance as about 1 in 400."

From their results, the researchers conclude that the top quark has a mass (expressed in energy units) of 174 billion electronvolts, with an uncertainty of about 10 percent. This makes the top quark nearly as heavy as a gold atom. The measured mass is also consistent with recent theoretical predictions.

The CDF team has submitted a 153-page paper describing its results to PHYSICAL REVIEW D. "The analysis is extremely complex," says Melvyn J. Shochet of the University of Chicago. "It was absolutely essential that we understand all the details . . . before we went public and presented it for publication."

"I'm persuaded that the evidence is very strong," says John Peoples Jr., Fermilab director. Still, researchers operating the DZero detector at Fermilab have failed so far to confirm the existence of the top quark, although they have seen a handful of "interesting" events. "We're not claiming a discovery," Carithers notes. "We're in that middle ground where the excess of events that we see is too large to ignore but too small to cry eureka."

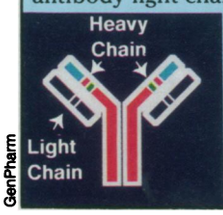
At this point, "it's important to collect more data," Shochet says. Indeed, the current experiment has already yielded at least one additional event that may have involved a top quark. — *I. Peterson*

Engineered mice make human antibodies

For years, monoclonal antibodies have teased investors and researchers alike with their potential as the wonder products of biotechnology. Scientists had harnessed the mouse immune system to tailor antibodies to target specific substances, including those that cause disease in humans. But these mouse-derived molecules can cause allergic reactions in people.

Now, two biotechnology companies hope to sidestep this problem by creating mice that produce human antibodies. They have used cells from these mice to make antibodies against human proteins.

Aya Jakobovits and her colleagues at Cell Genesys in Foster City, Calif., first made two new mouse strains by inserting yeast artificial chromosomes (YACs) into very early mouse embryos (SN: 6/5/93, p.360). One strain's YAC got genes for key parts of a so-called heavy chain in human antibodies. The other strain's YAC carried genes for a human antibody light chain.



GenPharm

Mouse-derived human antibody.

In general, cells mix and match various genes for these two chains to create many different antibodies. So the researchers bred these mice to create offspring with genes for both components of human antibodies. They mated the resulting generation of animals with mice whose genes for making mouse antibodies had been disabled, they report in the May NATURE GENETICS.

In the resulting young, "the human genes are using the mouse machinery to [produce and] process the antibody," says Jakobovits.

At GenPharm International in Mountain View, Calif., Nils Lonberg and his colleagues developed their new strain of mice similarly, but they used a different genetic approach. Instead of YACs, they made artificial genes called minilocus transgenes. The researchers created one minilocus by joining pieces of human DNA involved in heavy-chain production and two more miniloci using DNA involved in light-chain production, Lonberg's group reports in the April 28 NATURE.

In both companies' mice, the immune system rearranges these human genes to create a variety of antibodies known as IgM immunoglobulins. The GenPharm mice also make second-generation antibodies known as IgG immunoglobulins, says GenPharm's Robert M. Kay. — *E. Pennisi*