KEN WINOKUR

Physicist Melissa Franklin stands before a mural in her lab. She holds a mock-up of a calorimeter, a detector that can measure the energy of a subatomic particle.

Top Quark

Subatomic physicists point to evidence of the long-sought twelfth particle of their Standard Model. The breakthrough may be, in part, a political one.

On April 26 the news wires buzzed briefly with an announcement from Fermi National Accelerator Laboratory in Batavia, Illinois: 439 leading particle physicists—some 25 Harvard faculty, students, and alumni among them—had signed a 150-page paper suggesting evidence of a phenomenon known as the "top quark." That finding, if confirmed, would mark a watershed in the history of physics: a final experimental proof of the so-called Standard Model, the widely accepted theory that describes the structure of all matter.

But this was not a "discovery"—not yet. The results fall short of statistical conclusiveness. And while Fermilab scientists fully expect confirmation within the year, they decided to publish now because their results, in all likelihood, signal a major advance in pure science. The decision may also suggest the physicists' discovery of a somewhat less pure science: *realpolitik*. When Congress canceled the mammoth Superconducting Super Collider (SSC) last year—writing off a $3 billion investment and damaging hundreds of careers—particle physicists learned a painful lesson in the importance of good public relations.

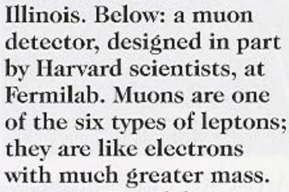
"So much depends on the vision of the people making the policy decisions," says Harvard professor of physics Melissa Franklin, a co-author of the paper. "Scientists need to find better ways of sharing their excitement about these kinds of discoveries, of explaining why this matters."

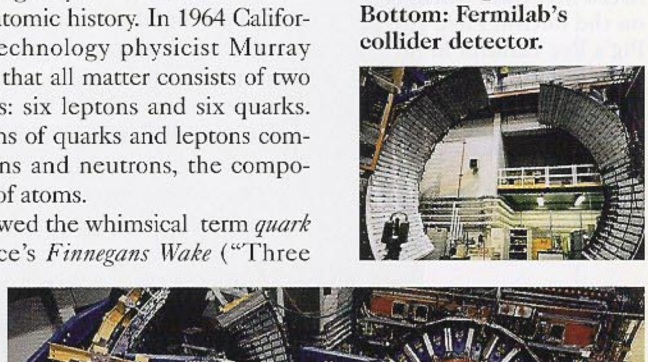
First, a little subatomic history. In 1964 California Institute of Technology physicist Murray Gell-Mann posited that all matter consists of two families of particles: six leptons and six quarks. Various combinations of quarks and leptons combine to form protons and neutrons, the components of the nuclei of atoms.

Gell-Mann borrowed the whimsical term *quark* from a line in Joyce's *Finnegans Wake* ("Three quarks for Muster Mark . . ."). In another flight of linguistic fancy, he described the possible pairings of quarks as *flavors*: up and down, strange and charm, bottom and top.

Over the last thirty years, experiments have confirmed the existence of all but the top quark. Part of the problem: its life span runs to approximately one trillionth of a trillionth of a second, making true observation impossible. Complicating matters further, the top quark has not occurred naturally (at least not in

Particle physicists did much of their searching for the top quark at Fermilab in Batavia, Illinois. Below: a muon detector, designed in part by Harvard scientists, at Fermilab. Muons are one of the six types of leptons; they are like electrons with much greater mass. Bottom: Fermilab's collider detector.





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WALKER ARTS CENTER

Artist Mel Chin working on the Revival Field site at Pig's Eye Landfill in St. Paul, Minnesota, at harvest time, 1993. Below: an aerial view of the Revival Field site.

our sector of the known universe) for at least ten billion years—since the fraction of a millisecond following the Big Bang.

To re-create the energies that might have produced the top quark, Fermilab created a five-thousand-ton, three-story device called the Collider Detector. By swirling protons and antiprotons in opposite directions at velocities approaching the speed of light, the machine forces subatomic collisions that convert energy into matter (fulfilling Einstein's promise of $e=mc^2$). At that moment the top quark is thought to exist, then decay into smaller particles, leaving only a whisper-trail of evidence behind. "The discovery of 'top' is complicated because many events could give us a fake signature," says Harvard professor of physics John Huth, also an author of the paper. "The systematics are tricky; there's always the problem of mis-estimating the probabilities."

Fermilab physicists think they have found that evidence. In fact, they are 99.75 percent sure of it. But that remaining 0.25 percent matters in a world where fractions are measured in trillionths. Conclusive proof, most physicists agree, would require a margin of error of only 0.01 percent.

If they can reach that expected proof, Fermilab physicists not only will have confirmed the Standard Model theory but also will have opened new doors of inquiry: What is the origin of mass? Why does time seem to move forward? "Most of the laws of physics don't recognize an arrow of time," says Huth. "The mass of 'top' is a critical parameter in poorly understood processes that seem to suggest an arrow of time."

Such questions might have proceeded much more smoothly with the help of the SSC, which was designed to investigate the forces (known as bosons) that influence quarks and leptons. Now these questions will have to wait for at least a decade, until the Europeans can complete construction on a similar collider project in Switzerland. In the wake of the SSC cancellation, one embittered physicist described the congressional decision as "the revenge of the C students." That remark—which Huth calls "unfortunate"—may have given voice to a common sentiment, but it won no points for diplomacy.

Physicists now realize the need to spread word of significant advances as soon as they happen. The SSC decision "was absolutely a motivating factor in the decision to publish," says George Brandenburg, another co-author and a senior research fellow in Harvard's physics department.

Melissa Franklin thinks scientists should assume a share of the blame for the recent decline in public and governmental support. Particularly troubling, she thinks, is the "Carl Sagan Effect": the stigma attached to scientists who try to communicate with the general public. "What science really needs is a forum," she says, "a way for scientists to involve themselves in public discussion of these issues. We need to find ways not just to explain what we're doing but to communicate why this stuff is so interesting. We need to call out to people and say: 'Come here, look. Let me show you why this is incredibly cool.' "

—A.G. Wright

Art Detoxifies

A series of collaborative ventures between artists and environmental scientists showcases ideas like phytoremediation—using plants to detoxify soil.

DAVID SCHNEIDER

What do you get when you combine a research agronomist with a visual performance artist? It may sound like a joke, but one answer is, "a compelling discussion of science, art, and the environment." Soils expert Rufus Chaney and New York artist Mel Chin recently presented their collaborative work, "Revival Field," as part of a series of public talks called "Invention/Intervention: Focusing the Arts and Sciences on the Environment," sponsored by the Harvard/Radcliffe Office for the Arts.

The first presentation featured nature writer Bill McKibben '82 and Buster Simpson, whose "Rolaids for Rivers" project to de-acidify the Hudson River got national attention. "Tornado artist" Ned Kahn, noted for his mist, light, and wind exhibits, followed, paired with Cathrine Sneed, founder of The Garden Project, a horticultural rehabilitation program at the San Francisco jail. Artist (and "patron saint of garbage") Mierle Laderman Ukeles and Environmental Industry Associations CEO Eugene Wingerter presented the third event in the series: "The Politics of Garbage and the Art of Sanitation."

At the fourth and final program, Chaney, a