Will Fermilab Get Its Upgrade?

The need to upgrade aging accelerators is not limited to labs on the two coasts. Officials at the Fermi National Accelerator Laboratory in Batavia, Illinois, where the bottom quark was discovered in 1977, have said they'd like to modernize their facilities by replacing the 20-year-old main accelerator ring with a new particle injector built in a separate tunnel. But to researchers at the lab, the improvement may be more than a timely facelift. "Without the new injector, Fermilab is dead," says one highly placed Washington, D.C., physicist who is responsible for securing funding for new physics projects.

Fortunately, then, the prospects for the new injector—and Fermilab's survival—look good at the moment. The injector's cost, $177.8 million, is modest, at least by the standards of high-energy physics. And last year, the High Energy Physics Advisory Panel (HEPAP) gave the new injector its top priority recommendation. (HEPAP's 1990 report did not consider the Superconducting Super Collider, a top priority in previous years that had already been approved.)

If Congress accepts the panel's recommendation, Fermilab will once again have a shot at some of the hottest particle physics going. The lab's physicists—who previously gave the world such advances as the first superconducting accelerator and the highest-energy proton-antiproton collider, would be able to increase the frequency of proton-antiproton collisions in Fermilab's Tevatron accelerator more than fiftyfold. This upgrade, coupled with a few other major modifications, such as development of a new particle detector, would improve the researcher's chances of catching the massive top quark. The Higgs boson, the SSC's target, and the top quark are the two remaining elements of the Standard Model, and therefore of great interest to high energy physicists.

And that's not all. Advocates of the Fermi upgrade, most notably including Nobel physicist Leon Lederman, the lab's most recent past director and now professor of physics at the University of Chicago, and John Peoples, the current director, say the enhancement would also allow study of the elusive tau neutrino and k mesons, thereby providing a better understanding of the difference between ordinary matter and antimatter. What's more, they claim, the new, improved Fermilab would also be able to do B meson studies similar to those planned for the "B factories" now being proposed for Cornell and the Stanford Linear Accelerator Center (see accompanying story).

But even though the injector has received HEPAP's blessing, the schedule for building it is by no means a sure thing. Although it has made the president's budget for fiscal year 1992, negotiations with Congress, and wrangling within the scientific community itself over which project or projects should be given the go-ahead and how fast they should be funded might still derail the project. The Department of Energy (DOE) already has SLAC's recently submitted B factory proposal, and if its budget remains relatively constant, as seems likely, then it may have room for strong support of only one major new physics project other than the SSC. Then again, DOE may choose to extend its limited resources by funding more than one project but at a slower pace.

Lederman doesn't see the B factory proposals as a threat. Ever the optimist, at least in public, he points out that HEPAP previously ranked B factories after Fermilab's injector, and he believes it unlikely that the panel will revise its recently stated priorities. "The committee knew the B proposals were coming and they could have withheld judgment until those proposals were in hand," he says.

But even Lederman acknowledges that in the coming years there will be pressure to shut down aging accelerators in favor of newer, more splendid models, such as the SSC. He notes that HEPAP has been recommending that strategy since it got into the assessment business in the mid-1960s. So there is ample reason for even the optimists to be developing frayed nerves. Consider the fate of the Princeton-University of Pennsylvania accelerator. When it opened at Princeton in 1963, it was the ultimate atom-smashing tool in high-energy physics. In 1971, however, the Atomic Energy Commission decided to concentrate its resources on the national accelerators and withdrew funding from the Princeton-Penn facility. Despite efforts to gain support from alternative sources, the facility was turned off in 1972. It succumbed to the wrecking ball a few years ago. Fermi's physicists don't want to see their high-energy lab succumb to that sort of a low-energy demolition derby.

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particles known as K mesons, or kaons, they noticed something unexpected, a violation of the principle of symmetry that proposed that particles and antiparticles should behave identically, provided that "you look at one of them in the mirror," as physicist Lincoln Wolfenstein of Carnegie-Mellon University puts it. But Fitch and Cronin found that the rate at which a neutral kaon turns into its antiparticle differs by about 0.2% from the rate at which the neutral antikaon turns into a kaon. That's a minute effect in the kaon system. Berkelman describes it as "a very small difference occurring with a particle that has a rare and fleeting existence."

Indeed, CP violation was much too small to be systematically investigated in kaons, but it has profound implications. As Andrei Sakharov pointed out in 1968, this tiny asymmetry between matter and antimatter might account for why the universe seems to be composed exclusively of matter. Or, as B factory proponent Richter puts it: "CP violation is why we're here."

And if that isn't reason enough to go after CP violation, there's another enticement as well. The effect is a window into the physics of the Higgs boson, one of two fundamental particles that have not yet been trapped by the high-energy physicists' mega-accelerators—and the main target of the SSC. Says James Bjorken of Stanford, "The parameters that characterize CP violation are about as fundamental as you can get. This field is not going to go out of fashion."

The High Energy Physics Advisory Panel (HEPAP) agrees. In 1990 the panel, charged with charting the path of high-energy physics through the pre-SSC years, "strongly" endorsed the idea of a B factory. HEPAP, however, ranked the concept after the SSC; a new injector for the Fermilab Tevatron, which wants to use it to look for the other remaining fundamental particle, the top quark (see box); and a healthy exploitation of present Department of Energy (DOE) facilities. But physicist Pier Odonne of the Lawrence Berkeley lab (LLB) points out, "Those recommendations were made a little over a year ago. At that point we didn't have a proposal."

They have one now because it's only been in the past 2 or 3 years that systematic characterization of CP violation even began to look practical. The idea itself only dates back 10 years to a paper published in *Physical Review Letters* in 1981 by physicists Tony Sanda and Ashton Carter, who were then at Rockefeller University. Sanda and Carter proposed that since B mesons are nothing but kaons with the strange quark replaced by the much heavier bottom quark, the B mesons might reveal considerably more about CP violation than kaons possibly could. They predicted that in certain decays of neutral B