tion, the lab has a Web-based catalog, well-documented cores, and a clear policy for removing materials from the collection so that little core is wasted.

The private sector also boasts examples of good practice. When Shell donated 670,560 meters of core to the Texas Bureau of Economic Geology (BEG) in 1995, it threw in a warehouse and $1.3 million for operating costs. In return, the company received tax write-offs. "It's a good model," says BEG director Scott Tinker, "but it has to be customized for each company." Tinker expects to announce another major donation of a facility and 400,000 boxes of core shortly. The NRC panel suggests further incentives to encourage this kind of donation.

Such measures, however, address just a fraction of the problem. To make a bigger impact, the NRC panel recommends that the government fund three new centers to hold core and other materials, modeled after the NICL and the core repository of the international Ocean Drilling Program. At $35 million to $50 million, each facility would cover 16,000 square meters, about the size of a Wal-Mart Supercenter. The centers would relieve the problem of data loss for 10 to 20 years, Indiana's Maples estimates.

Mustering support for such a major investment will be difficult. "Storing rock isn't sexy," Landon says. "It's long-term housekeeping that's always going to have trouble competing with other scientific expenditures." Yet proponents say such large, unglamorous efforts are the only way to avert every scientist's nightmare: losing irreplaceable samples. "It's a sobering thought, and it's not hard to imagine," Allmon says. "Even with just benign neglect, all these data could slip away."

–ERIK STOKSTAD

RESEARCH MANAGEMENT

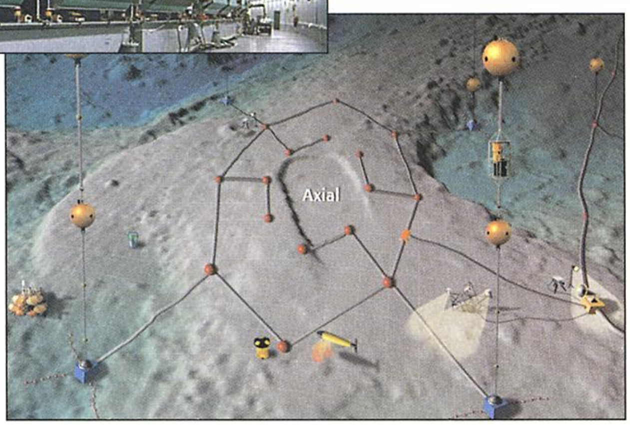
Big Facilities Account Is Big Headache for NSF

Legislators are pressuring NSF to explain its procedures to researchers with large projects that have been approved but not funded

In 1994 the National Science Foundation (NSF) wanted to find a way to keep new and expensive facilities from eating into its regular research budget. So it created a separate account and used it to fund a handful of projects, from a new South Pole station to mountaintop observatories. But less than a decade later, a growing portfolio is forcing NSF to face management challenges that it never imagined—and to defend itself against criticism by Congress, scientists, and its own internal auditor.

In the past couple of years, big facilities have become a big headache for NSF. One problem is a backlog of projects approved for funding by the National Science Board, NSF's governing body, that haven't made it into the agency's budget. Researchers whose projects have been passed over complain that NSF has kept them in the dark about why they didn't make the cut while others did, and some have convinced members of Congress to do an end run by ordering NSF to fund specific experiments. Last month several influential U.S. senators asked the National Academy of Sciences (NAS) to review how NSF makes those decisions. If that were not enough, NSF's own inspector general (IG) recently issued a report questioning how the agency manages existing projects. NSF hopes to blunt the criticism by naming a well-regarded facilities construction chief to a new office, but so far it has been unable to hire anyone on a permanent basis.

To NSF officials, most of the headaches could be cured with money. Its approach, using what's known as the Major Research Equipment (MRE) account, worked reasonably well when the number of projects approved by the science board roughly equaled the number that could be funded. But last year, President George W. Bush sent Congress an NSF budget that included no new starts. This year, the foundation's budget request includes $126 million for the MRE account, enough to start two projects and continue building five others. That has left four projects in limbo—approved, but unfunded—and several others close to approval, with backers wondering if they will ever get off the ground. Climate modeler Warren Washington, who chairs the science board, says that NSF needs to "double or triple" the current level of MRE funding to satisfy the community's growing hunger for cutting-edge instruments. "We're all working toward a common end, and that end is an increased budget," says NSF deputy director Joseph Bordogna.



Concrete ideas. NSF hopes to get money to build new research facilities at (clockwise from upper left) Brookhaven, the South Pole, and the Pacific Ocean floor.

CREDITS: (CLOCKWISE FROM TOP) ICECUBE/UNIVERSITY OF WISCONSIN; NEPTUNE PROJECT AND THE CENTER FOR ENVIRONMENTAL VISUALIZATION, UNIVERSITY OF WASHINGTON; BROOKHAVEN NATIONAL LABORATORY

The excess demand has, however, exposed flaws in the system. The science board doesn't prioritize the projects it approves. Until Congress last year demanded the names of all approved projects (*Science*, 14 September 2001, p. 1972), NSF had never publicly identified individual projects until they appeared in the agency's budget request. That secrecy bred discontent. The process appears "ad hoc and subjective," wrote six senators in a letter to NAS president Bruce Alberts last month that also complains about NSF's failure to explain how the system works. The senators, the chairs, and ranking members of NSF's spending and oversight committees asked Alberts to appoint a committee to review NSF's priority setting.

NSF officials bristle at such criticism. "Every project goes through an extensive review, and we are totally transparent about how this takes place," says Bordogna. "But we'll certainly listen carefully to what the academy has to say and act accordingly." NSF and academy officials are negotiating the terms of the study, which could be completed by early next year.

At the same time, the agency's own watchdog is pointing to holes in how current projects are managed. On 15 May, NSF IG Christine Boesz delivered a report to the Senate panel that sets NSF's budget, warning that the current accounting system does not guard against potentially large cost overruns. "NSF's policies and practices do not yet provide adequate guidance for program managers to oversee and manage the financial aspects of major research equipment and facilities," Boesz declared.

The report angered former presidential science adviser John Gibbons, who in a letter to the panel accused Boesz of "harassment" of NSF director Rita Colwell. The panel's chair, Barbara Mikulski (D–MD), and ranking member Kit Bond (R–MO) rushed to Boesz's defense, however, writing Gibbons on 10 June that the IG "has acted professionally and fairly … and has played a crucial role in protecting the interests of the American taxpayer." In its reply to the IG report, NSF defends its procedures and notes that it expects to have revised guidelines to further tighten up those practices by the fall.

NSF hopes its new office will also improve the situation. But it failed to deliver on a promise last fall to the House Science Committee to have the top job filled by January. NSF's first choice was James Yeck, project manager for the U.S. contribution to Europe's Large Hadron Collider. An 18-year veteran of large research projects at the Department of Energy and a politically savvy outsider, Yeck could have bestowed instant credibility on the beleaguered program. But in May, for personal reasons, he turned down NSF's offer to move from Illinois's Fermi National Accelerator Laboratory to suburban Virginia.

Yeck thinks that Boesz's criticism of the agency's accounting practices is "unfair." But he agrees with her recommendations for improving NSF's cradle-to-grave fiscal management of large projects, including better tracking of a project's total costs and making contingency plans for any overruns.

In the meantime, some approved projects are moving ahead without NSF's official monetary endorsement. Last year IceCube, a neutrino detector under the South Pole, received $15 million after supporters won over an influential appropriator, Representative David Obey (D–WI). And last month, Representative Felix Grucci (R–NY), who represents Brookhaven National Laboratory, asked House appropriators to earmark $26.6 million in NSF's budget to start building a proposed physics experiment at the lab, Rare Symmetry Violating Processes. "It's ready to go, and we hope to get it funded," says an aide to Grucci.

That request, and others like it, suggests that NSF has its hands full trying to satisfy both the scientific hunger for new projects and the political demand for greater oversight. —JEFFREY MERVIS

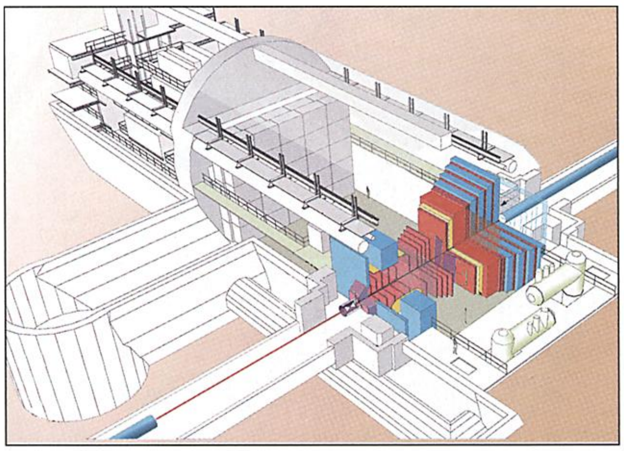
HIGH-ENERGY PHYSICS

Shadowy 'Weak Force' Steps Into the Light

After decades of work, the most mysterious of the fundamental forces of nature is poised to come into much sharper focus

The nuclear weak force is making strong claims on scientists' attention. A member of the quartet of fundamental forces in the universe, the weak force is feebler than the strong force that binds protons to neutrons and shorter range than both the electromagnetic force that ties electrons to atoms and the gravity that keeps stars and galaxies from flying apart. It is also particularly difficult to study. It exerts a subtle pull on matter and ignores common-sense rules that other forces obey. For example, the force behaves differently if you reflect it in a looking glass—behavior unlike anything else in physics.

Its quirky character makes the weak force irresistible to physicists. For more than 3 decades they have studied how the force interacts with quarks, the fundamental particles that make up most of the ordinary matter in the universe. Now, with that quest nearing its goal, they are gearing up to continue the exploration with a radically different class of particles: neutrinos. The past few weeks alone saw the debut of the MiniBooNE detector, a million-liter tub of mineral oil at Fermi National Accelerator Laboratory (Fermilab) in Batavia, Illinois, and the dedication of the MINOS detector, an enormous set of neutrino-detecting plates in Soudan, Minnesota. Other labs are following hot on their heels, in hopes of understanding the full nature of the weak force. "By experimenting in the neutrino sector," says Michel Spiro of France's Center for Atomic Energy in Saclay, "we're writing a new chapter in *Alice in Wonderland*."



B-dazzler. Now under construction, B-particle detector at CERN's Large Hadron Collider will boost weak-force studies to new energies.

CREDIT: CERN GENEVA

News of the weak

The through-the-looking-glass properties of the weak force puzzle and delight the physicists who try to understand it. Unlike the strong, electromagnetic, or gravitational forces, the weak force can change the identity of a subatomic particle, transforming an up quark, say, into a down quark or an electron neutrino into a muon neutrino. The force's parlor tricks first came to light in the early 1930s, when physicists were puzzling over a subatomic process known as beta decay. If you watch a clump of cobalt-60 long enough, a neutron in one of its atoms will spit out an electron and become a proton, turning the cobalt atom into nickel. That transformation, the beta decay of the neutron, seemed to violate one of the most hallowed rules of physics, the conservation of momentum. When physicists compared the "action" of the hurtling electron with the "reaction" of the recoiling proton, a little bit of recoil remained unaccounted for.

German physicist Wolfgang Pauli sought to close the gap by suggesting that, along with the electron, the neutron emitted a tiny neutral particle. In 1934, his Italian colleague Enrico Fermi dubbed that particle a "neutrino" and explained beta decay by invoking a new force, the weak force. Today, physicists realize that beta decay is caused by the interaction of a quark with a carrier of the weak force known as a W particle. In cobalt-60, the W turns a neutron's down quark into an up quark, changing the neutron into a proton and emitting an electron and a neutrino (technically, an antineutrino) in the process. Fermi's version "didn't talk about exchange of particles, but it described beta decay beautifully," says Jim Cronin, a