Lab Report Puts SSC Magnets in Limbo

Rather than "fine-tuning," the particle collider magnets may require extensive redesign in a major R&D effort through 1992

FOR MORE THAN A YEAR the high energy physics community has been nervous about problems with magnets being developed for the Superconducting Super Collider (SSC). They are the heart of the proton smasher, and their performance will critically affect scientific productivity. Although the Department of Energy (DOE) already has spent 4 years and more than $100 million designing and developing the magnets, an internal report* obtained by *Science* suggests that they may have to undergo a major redesign to assure that the SSC will work properly.

The closely held review, prepared for Roy Schwitters, the director of the new SSC Laboratory in Texas, confirms problems reported earlier this year (*Science*, 17 March, p. 1425). The magnet troubles include inadequacies in the strength of the magnetic field, potential beam focusing problems, and unanticipated mechanical stress.

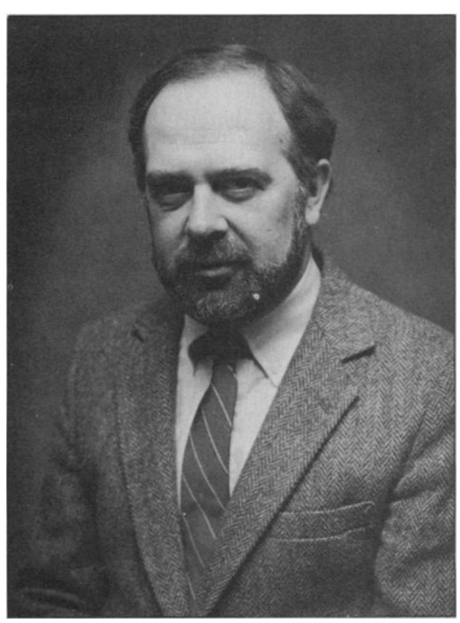
Schwitters, who took over management of the SSC project last winter, assembled 24 physicists and engineers this spring to take a hard look at the performance of dipole magnets developed by DOE's Central Design Group.

The group's final report, which was submitted to Schwitters on 1 June, concluded that "these magnets are not satisfactory for operation. . . ." Earlier this year DOE officials claimed that only "fine-tuning" was needed to complete the design. But the review panel advised Schwitters that fixing the magnets will require far more than that, urging "a strong R&D effort" through 1992.

This news could not come at a worse time for the scientist-managers of the venture. Universities Research Associates (URA), the operator of Fermi National Accelerator Laboratory and the SSC's general contractor, has been locked in a struggle with DOE over how much day-to-day control department bureaucrats will have over the massive project. The report could bolster the Office of Energy Research's bid to set up a large supervisory office to oversee the URA's management and the operations of the newly established SSC Laboratory in Texas.

Even more threatening is the possibility that congressmen who have so far tried—and failed—to scuttle the project may use the report as ammunition in a renewed attack on the SSC. The report had not been circulated to legislators when the House and Senate voted on the SSC's 1990 appropriation. Before going on summer break in August, they agreed to plunk down about $200 million for the SSC this year, but the final appropriation will not be set until a conference committee meets after Labor Day. It will be difficult for long-time opponents like Representative Don Ritter (R–PA) to change this year's SSC budget, but he and others may use the report next year as justification for stopping the project. Congress may balk if, as expected, it is asked to increase SSC funding dramatically to $900 million in 1991.

Without sufficient funds, particle physicists will surely not be able to pull off what is to be one of mankind's most sophisticated technological achievements. The SSC is designed to accelerate two beams of protons in opposing directions to an energy of 20 trillion electron volts (TeV)—a velocity near the speed of light.



Dipole doctor. *Lab director Roy Schwitters must prescribe a cure for the magnets soon.*

To accomplish this, the magnets must keep trillions of protons focused in a tight orbit as they zip around the 53-mile collider ring until bunches are siphoned off and smashed together at a record energy of 40 TeV. The collisions are expected to produce rich showers of hadrons, leptons, photons, and other particles that will provide physicists with a new window on the structure of matter. The aim is to expand man's understanding of the fundamental forces of nature by peering deep into the structure of basic particles and searching for new ones.

To obtain 40-TeV collisions on a regular basis, nearly 8000 dipole magnets and almost 2000 other navigating magnets must operate at least 6.6 teslas. But the review panel told Schwitters that the magnets, which could account for more than one-quarter of the SSC's price tag, do not have sufficient operating margin "for trouble-free operation."

This conclusion supports what many physicists have been saying privately for some time—that the SSC magnet performance specifications were inadequate from the outset. In fact, only one of the magnets built to date, the panel noted, has performed as required. The reviewers concluded that a 10% margin in the magnet operating field must be achieved to attain the desired collision energy.

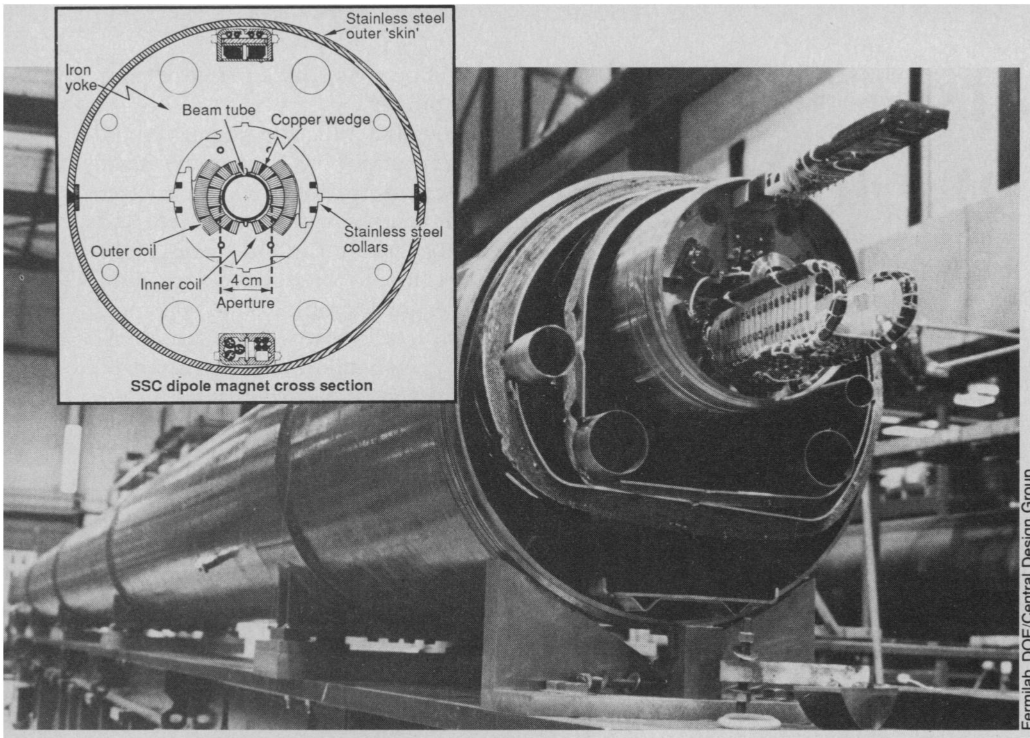
Another problem that could affect the quality of science at the SSC is reduced luminosity, which could occur if the number of observable proton collisions drops off. This could occur if the magnets are unable to maintain the protons in a tight focus as the protons are injected into the 53-mile SSC ring and then are accelerated.

Still another worry is that there might not be enough room in the magnets' hollow core, or aperture, to maneuver the beam of protons. If the current 4-centimeter aperture size is just barely sufficient, then day-to-day operation of the SSC could be cumbersome.

Fortunately, there appear to be a number of ways to deal with some of the SSC magnets' afflictions. The simplest and cheapest way to overcome inadequate magnet field margins would be to stick with the current design and accept a lower collision energy of around 36 TeV. As for keeping protons focused in a tight beam as they rocket into the SSC ring, this problem might be overcome by increasing the injection energy from 1 TeV to 2 TeV.

"Little would be probably lost in the physics," says Robert Diebold, director of DOE's SSC magnet division, if the collision energy were reduced. Indeed, at 36 TeV the SSC still would be nearly twice as powerful

Report of the SSC Collider Dipole Review Panel, 1 June 1989.



Marginal Magnet. *A sealed SSC magnet sits inside a 24-inch cryogenic shell awaiting tests at Fermi National Accelerator Laboratory in Illinois. It may be necessary to enlarge the aperture (see inset) to 5 centimeters in order to upgrade overall magnet performance.*

as its nearest competitor, the 20-TeV Large Hadron Collider, which has yet to be approved by the Center for European Particle Physics. For the moment, however, abandoning the goal of 40-TeV collisions seems to be out of the question.

One shortcut that might enable DOE to stick with the design specs would be to run the helium-cooled magnet at a lower temperature—3.5 K, instead of 4.35 K as currently required. At the colder level the existing magnets would produce stronger fields and thus gain operating margin. But this approach also might produce operating problems, including a higher rate of magnet failures. Electricity costs for running the magnet cooling system also would rise.

"It's a question of how conservative you want the magnet design to be," says Helen Edwards, the director of accelerator systems at the SSC Laboratory. A recent defector from Fermilab, Edwards favors sticking with the planned 4.35 K specification, noting that it might be prudent to hold the lower temperature option in reserve in case other operating problems crop up after the collider is built.

So far, neither DOE nor physicists working on the SSC have decided to take either of the easy ways out. Instead, a team at the SSC Laboratory in Texas recently has begun studying the merits of a bolder technical solution: scaling up the entire magnet structure, starting by enlarging the aperture from 4 to 5 centimeters. The surrounding superconducting magnet coils, the collars that confine the coils, and the iron yokes that clamp around the collars also would have to grow bigger.

The advantages are many. "Some operational margin has to be gained," says Romeo Perin, a CERN physicist who served on Schwitters' SSC magnet review panel. A slightly bigger magnet, he told *Science*, not only provides a way to raise the magnet field and greatly improve control of the beam focus, but it also reduces mechanical stresses and fabrication problems. That view is also supported by Richard Lundy, who had a central role in building the magnets for Fermilab's Tevatron and helped write the SSC magnet assessment report.

But increasing the size would have two major drawbacks. The first is cost: several years ago DOE estimated that production costs would be 16% higher for a magnet with a 5-centimeter bore. Thus, the SSC would face a hefty and unexpected new bill for a small change in design. The second drawback is that stepping up the magnet aperture could delay by 2 years DOE's plan to have prototypes manufactured in 1992.

To avoid the delay, the review panel said industrial involvement in magnet development should begin as planned in January using the 4-centimeter aperture magnets. At the same time, however, the report said a special group of federal laboratory experts could be assigned to develop a second group of magnets with a 5-centimeter aperture.

Schwitters and DOE will not face a decision on these complex alternatives for several months. Schwitters told *Science*, however, that at this point nothing about the SSC design is sacred. Indeed, magnet guru Richard Lundy has advised Schwitters to build in all the extra performance margin he can, even if it takes a little more time and money.

Whether Congress will be willing to pay for the extra performance remains to be seen. One fact that may affect the legislators is DOE's reestimation of SSC project costs, which is slated for completion in December.

But even with mounting pressures, Schwitters is mindful of the need to make the SSC shine. He claims he will not be shy about asking Congress for new money. Says Schwitters, "We are the guys that have the responsibility to actually build this thing and make it work well." ■ MARK CRAWFORD

Shiseido Grant: More Than Skin Deep

Massachusetts General Hospital and Harvard University have just captured one of the biggest grants for basic research ever awarded by a company. The giant Japanese cosmetic firm Shiseido Company on 2 August announced a whopping $85-million pledge to the hospital and Harvard to establish a new skin research center, to be headed by John Parrish, chairman of the dermatology department at Harvard Medical School.

The 10-year Shiseido grant is a boon for MGH-Harvard and for basic dermatology research, coming at a time when federal funding in this area is being cut back. The agreement adds about 35 new research positions to the 50 full-time professors on the dermatology faculty. In addition, Harvard and MGH will get a steady influx of dollars, since they'll take in more than half of the $85 million to cover "indirect costs."

Beginning this October—housed in a former rope factory near Boston Harbor that has been converted into a laboratory and will be called the Cutaneous Biology Research Center—scientists will study the effects of light on skin (Parrish's specialty), cell differentiation, immunology, and the biology of skin pigments, such as splotchy red birthmarks known as "port wine stains."

Parrish, who pioneered a clinical therapy for psoriasis, has been eager to expand the institutions' current research on the structure and function of healthy and diseased skin. A year ago, he broached the idea of creating a new center with Shiseido, which has sent about 45 researchers to MGH-Harvard laboratories during the past 20 years.

About the same time, Shiseido, whose new corporate theme is "Graceful Aging,"