

AMAZING RACE: THE SSC CONTEST GENERATES DISORDER AND DISCORD

Though the SSC is still nearly a decade away from its first collisions, it is already the source of collisions of a different kind. And since most of the collisions involve politics, not protons, their outcome may be decisive in determining the ultimate fate of the Superconducting Super Collider.

Virtually everything connected with the proposed giant particle accelerator is now mired in controversy and contentiousness—from the site selection process, which has upset some key members of Congress and several governors whose states are no longer in the running, to concerns that management of the project by the Department of Energy is clumsy.

There is broad agreement that the SSC would be an impressive technical achievement and a unique research instrument with which to unlock some of nature's mysteries. Particle physicists and the Reagan Administration are convinced it is also one of the most conspicuous ways to reassert American scientific supremacy. But building the mammoth machine, with its 53-mile oval tunnel for countercirculating proton beams of 20 TeV each, is likely to cost about \$5.3 billion by the time it is completed.

The SSC epitomizes "megabuck" science. It ranks near the top of the R&D initiatives competing for massive amounts of dollars from the government in the current period of stringent budgets. Among the other "megascience" projects introduced during the Reagan era are the space station, the National Aerospace Plane, the Strategic Defense Initiative and the human genome program. The only basic physics project on this list, the SSC, deeply divides the physics community, largely because of its cost and emphasis. The polarization is mainly over priorities: big science or little science, crisis response or attention to long-term needs, national preeminence or international cooperation.

The first expression of disagree-



Rose Garden ritual for the SSC featured Energy Secretary John Herrington, who is at the podium addressing DOE's high-school honors students. On platform (left to right) are Samuel Ting, Burton Richter, Labor Secretary Ann Dore McLaughlin, Steven Weinberg, President Reagan, James Cronin and two honors students, Greg Griffin of Gretna, Louisiana, and Tene Young of Washington, DC.

ment over scientific priorities appeared right after the publication of "The Super Collider: A Machine for the Nineties," coauthored by Sheldon L. Glashow (Harvard) and Leon M. Lederman (Fermilab), in the March 1985 *PHYSICS TODAY* (page 28). Ever since, champions and critics of the machine have spoken out feistily from the magazine's letters columns. Even when the principal venue shifted to the committee rooms of Congress, the polemics on the SSC persisted—to the chagrin of many physicists. Indeed, discord over the SSC has become so serious that it motivated Frank Press, president of the National Academy of Sciences, to use it as his theme in an unusually astringent address at the organization's 125th annual meeting on 26 April. At a time when scientists should be celebrating their "dazzling

progress in almost every field," said Press, "this sniping and carping . . . is disturbing and destructive." He argued that "our internal dissension and the mixed, conflicting and self-serving advice emanating from our community are threatening our ability to inform wise policymaking." (Press was a geophysicist at Caltech and MIT, then President Carter's science adviser, before becoming head of NAS.)

It certainly didn't help eliminate factionalism when the Energy Department introduced the idea of a competition among the states to win the SSC. The proposed project had the whiff of pork about it: The SSC promises something like 5000 jobs during its construction, which lobbyists for the concrete industry have already dubbed "the big pour." Once

running, the SSC lab is likely to permanently employ at least 2500, principally scientists, technicians and maintenance workers, as well as to attract some 500 visiting physicists from universities and high-energy research centers in the US and abroad. The winning state, in addition to its benefit from the lab's annual budget of about \$270 million (in 1988 dollars), is bound to boom with new jobs, new housing and new businesses. It also is certain to gain the prestige that goes with playing host to the crown jewel of particle physics.

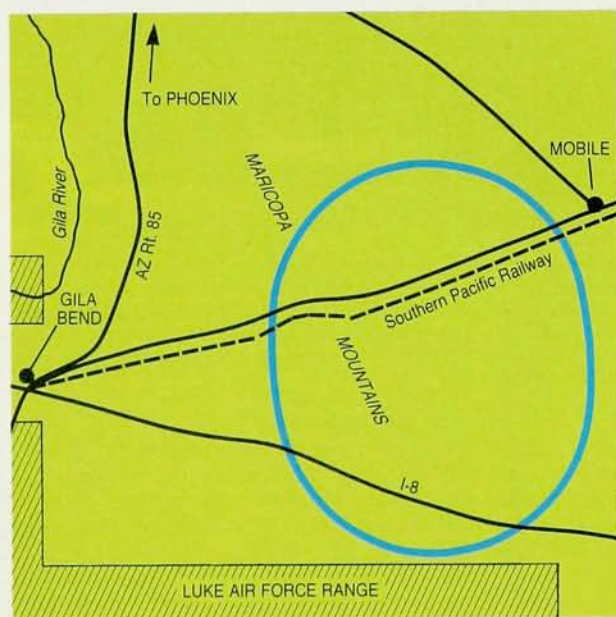
President Reagan approved the project on 30 January 1987 (PHYSICS TODAY, March 1987, page 49), and, not surprisingly, 43 proposals for the SSC arrived at DOE's doorstep by deadline day last 2 September. Not all of the bids had the formal approval of their states. One offered a site straddling New York's border with Canada—an international location the DOE rules forbid. Another was so far out, at a spot between the Earth and the Moon, that it was considered a joke. Five other entries did not qualify either

because there was no way for the Federal government to obtain the land without cost to the Treasury or because they carried unacceptable environmental burdens. Still, DOE officials found 36 sites from 25 states that met the qualifying criteria for competing in the race for the SSC. Right after Labor Day, DOE trucked some three tons of proposals to the NAS building, so that a 21-member committee appointed by the National Academy of Sciences and the National Academy of Engineering could cull the "best qualified list" (PHYSICS TODAY, November 1987, page 45).

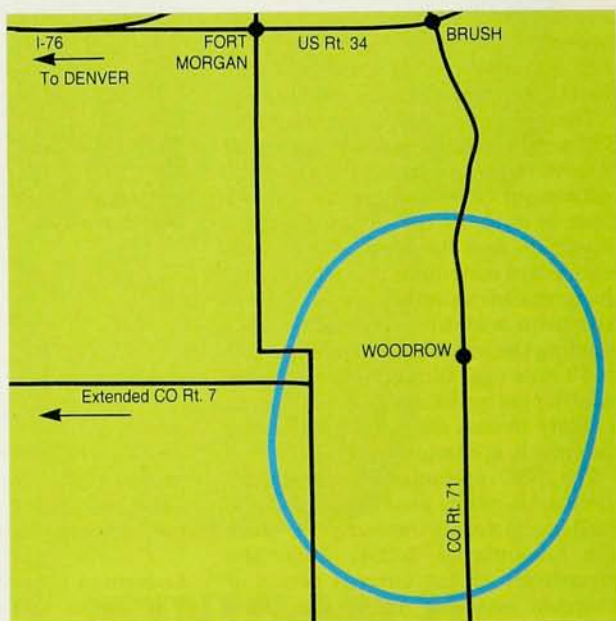
On Christmas Eve the Academies delivered to DOE a "short list" of eight best-qualified sites in as many states. As might be expected, there were sore losers. Many governors and members of Congress objected to having their states cut from the list, complaining to Energy Secretary John Herrington that their sites were as qualified as those of the finalists. A few threatened lawsuits. Trent Lott, an eight-term Republican congressman from Mississippi,

went further, asking the General Accounting Office, Congress's investigative watchdog, to determine whether the Academies had conducted a fair selection.

Meanwhile, committees in Congress have held more than a half-dozen hearings on the SSC. On 22 March, for instance, the House Committee on Science, Space and Technology listened for nearly six hours to Joseph F. Salgado, DOE's under secretary who has been point man for the SSC, and Raphael Kasper, executive director of the National Research Council's Commission on Physical Sciences, Mathematics and Resources and project director of the site selection committee. Salgado was barraged by Representative Manuel Lujan Jr, the senior Republican on the House science committee, who voiced dismay that his state, New Mexico, had been omitted from the Academies' list. Lujan also objected to the fact that a majority of selection committee members are affiliated as faculty or contractors with the Universities Research Association, which



ARIZONA The proposed site in the southern part of Maricopa County is about 35 miles southwest of Phoenix. One advantage is that it is situated in desert plains bisected by the Maricopa mountain range. Another is that most of the 224 parcels of land required for the SSC are owned by the Federal government and there are only a handful of homeowners. The geology is favorable for a combination of cut-and-fill and tunneling methods. Water seepage is unlikely because the ring would pass through unsaturated material and lie above the water table. The region has a large pool of technical staff who work in nearby electronics and semiconductor manufacturing plants and scientific laboratories. No adverse environmental impacts are foreseen. A possible disadvantage is that the main line of the Southern Pacific Railroad crosses the site—though state officials claim train vibrations could be mitigated. DOE estimates of life-cycle costs are slightly higher than those for other sites.



COLORADO Located about 65 miles northeast of Denver, the site is made up of moderately hilly grasslands with few residents or property owners. The geology is simple and predictable, consisting entirely of Pierre shale, an impermeable layer of bedrock that would enable conventional tunneling machines to burrow rapidly. Even so, the shale would need to be sealed to prevent slaking or crumbling when exposed to air, and surface structures would need deep foundations. DOE and the Academies committee express concern about the distance between the site and available worker pools and about housing and cultural amenities. A major airport, Stapleton, is also far away, although a new airport is being built some 10 miles closer. Oil pumping at nearby wells could cause vibrations. According to DOE, life-cycle estimates of SSC construction and operation costs are slightly less than for a similar facility at any other site, but the margin of error in such calculations is large.

serves as a board of directors for both Fermilab and the SSC Central Design Group. He remarked that the connection "on the face of it... sounds absurd." To the accusation that the choices were made unfairly, Salgado admitted that the selection process may have been "imperfect." He added, "Everything we do in human endeavor is imperfect."

Kasper explained for his part that the selection committee had only three months to come up with an unranked list of best qualified sites. In the circumstance, he said, the members only had time to evaluate the proposals submitted by the states under the criteria provided by DOE. The committee also used DOE's life-cycle cost estimates, based on assumptions about construction and operation costs for a period of 25 years. The committee did not visit any sites and did not attempt to assign numerical scores to any of the features at the sites or to the sites themselves. The most important criterion was the suitability of the geological conditions for construction and operation.

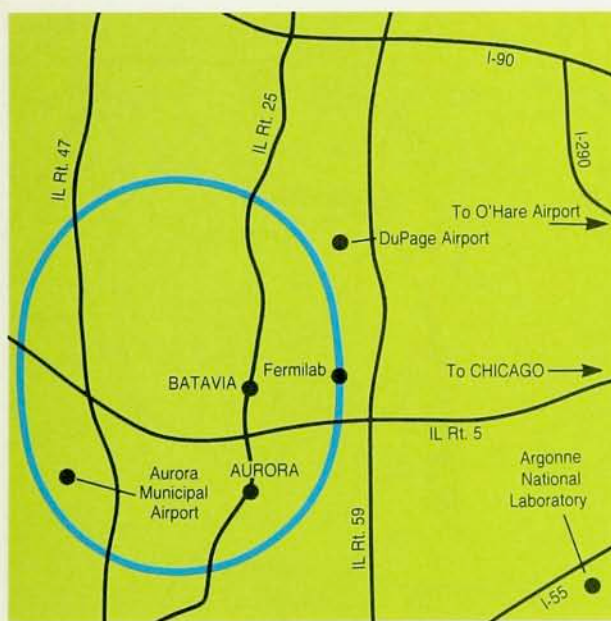
All 35 proposals met the DOE's qualification criteria, Kasper observed, and the best eight had the committee's unanimous agreement, "without dissent."

It turns out that DOE approved only seven of the sites, because shortly after the Academies handed over the report, New York Governor Mario Cuomo withdrew the site near Rochester. Citizens of the area had voiced objections to being relocated and feared that they would not receive fair value for their property. Some also expressed anxieties about the possibility that the machine might release nuclear radiation in the event of a mishap. A few likened the SSC to a "Chernobyl waiting to happen."

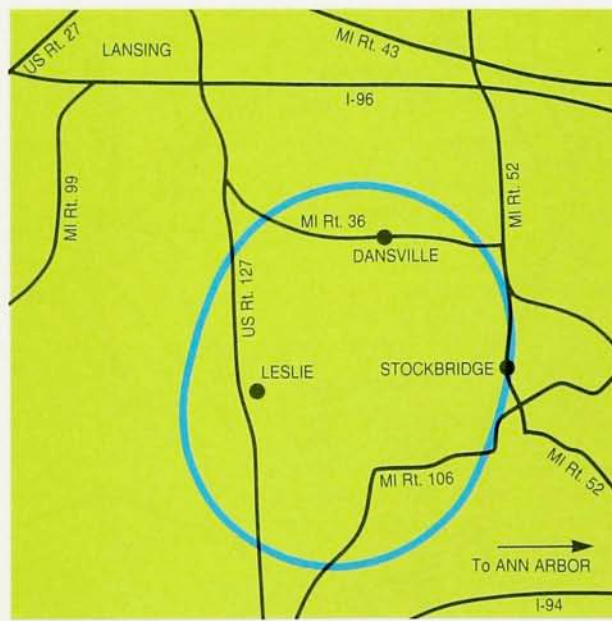
DOE now has completed dozens of public hearings at all seven sites. Between April and July it is engaged in examining the geological and environmental conditions of the sites (see maps and descriptions).

At the House hearing on 22 March, Salgado was confronted by a wide range of questions. Representative Robert A. Roe, the New Jersey Demo-

crat who heads the House science committee, wanted to know why DOE persisted in asking to transfer \$8 million from unobligated department management funds to the SSC account to carry out site evaluations after both Senate and House appropriations committees had denied the request. He also wondered, he said, why DOE had decided to postpone naming the preferred site from July until the end of November and whether the delay would affect the cost of the selection process. On Capitol Hill the conventional explanation for the postponement of the choice of location is that the Administration prefers to wait until after the November elections, for two reasons: Once the location of the SSC is named, Congressional support for the project is sure to wane, and the fiscal 1989 SSC budget request for \$363 million, which includes first-year construction costs, is apt to have fewer supporters. In addition, Secretary Herrington and other Administration leaders want to know whether the next President and Congress are firm-



ILLINOIS This site is 40 miles due west of Chicago, adjacent to Fermilab and about 30 miles northwest of Argonne National Lab. The SSC tunnel would be excavated in uniform dolomite, though the depth would be between 270 and 430 feet to avoid groundwater. The ring would be well beneath gently rolling prime farmland, the Fox River and wildlife-bearing wetlands. Some local farmers and townspeople vehemently oppose the SSC. The Chicago area offers many educational, cultural and recreational facilities as well as an extensive transportation system, including two major airports, and a labor force familiar with high-tech operations. Significant advantages would be the use of Fermilab's Tevatron as a proton injector for the SSC and an existing research infrastructure built on almost two decades of experience with an outstanding high-energy physics center. When such components are considered, DOE estimates of life-cycle costs are relatively low.



MICHIGAN Roughly 35 miles away from both the University of Michigan at Ann Arbor and Michigan State University at East Lansing, the site at Stockbridge is in a relatively flat, rural, farming region. The geology consists of shale, dolomite, limestone and sandstone, which would enable tunneling to proceed fairly rapidly. But an abundance of streams, wetland habitats and groundwater, as well as the risk of encountering a buried valley, would make tunneling difficult. Dewatering of shafts and the construction of slurry walls for the SSC's experimental halls would be necessary. The area's assets include a highly skilled worker pool and diversified housing and recreational sources. A number of highways and railroads cross directly over the proposed SSC site. The state has a complex plan for acquiring the land from some 700 owners. DOE figures that the life-cycle costs for a super collider at the Stockbridge site would be just about equal to the average for all the locations.

ly committed to the super collider and where the new power base lies in Congress. It has not escaped notice that House Speaker Jim Wright and the Republican Presidential contender, George Bush, are from Texas, which is fielding one of the sites for the SSC.

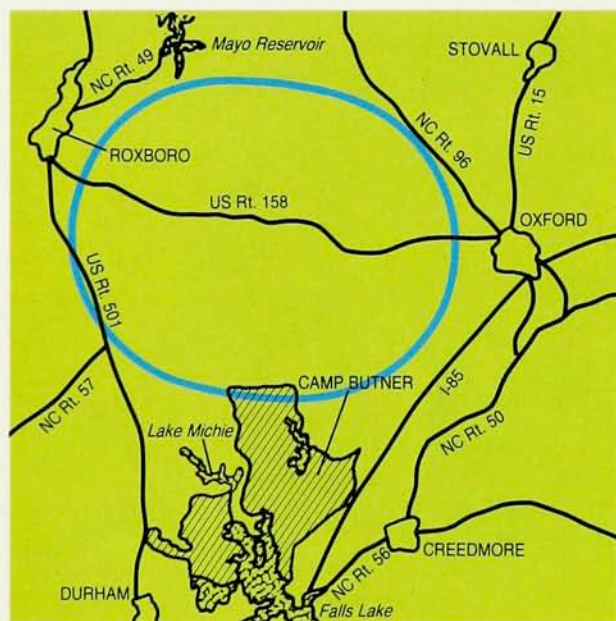
DOE sources say such views are cynical. In his reply to Roe's questions Salgado said the reason for delaying the final selection was to complete extensive investigations of the seven sites. As for the \$8 million the department wants to add to SSC funds, said Salgado, that's needed because DOE had not anticipated that the site surveys would take so long and cost so much. "We've already spent \$3 million and it's going to take \$5 million more," he asserted. Up to now the money has all come out of this year's total \$25 million allocation for R&D, which is being rapidly depleted, Salgado said. Unless the money is restored to R&D, he warned, staff at the Central Design Group will be cut back and work on the prototype magnets will be slowed.

The situation is similar to the cash-flow deficiencies that many businesses encounter. When Representative David Nagle, a freshman Iowa Democrat, spoke about keeping better books on the SSC to make sure the project isn't at risk of running out of funds, Salgado admitted that the funding problem "was a screw-up, to be perfectly honest."

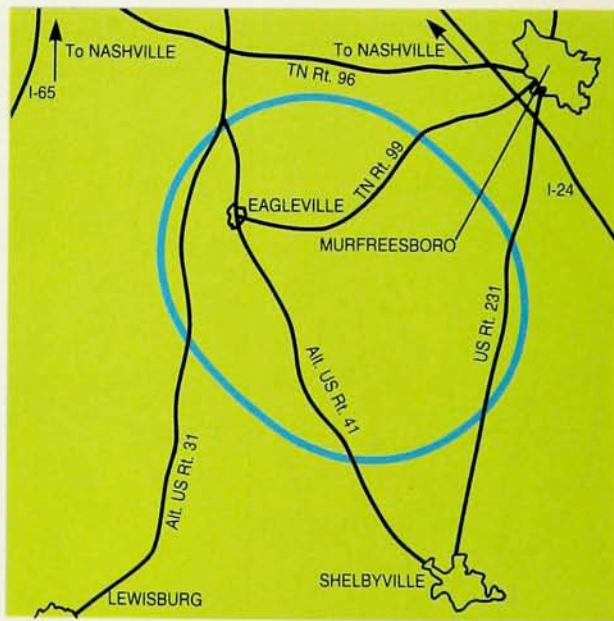
During the last two weeks of April, Congressional leaders and DOE executives reached an agreement about the \$8 million—though cutbacks in the R&D program may still be necessary. Before then, several influential members of Congress had refused to allow DOE to reprogram funds from its unobligated management account, claiming that the 1988 budget resolution had placed a \$25 million cap on all SSC funding for the year. In the end, however, Tom Beville, the Alabama Democrat who heads the House Appropriations subcommittee on energy and water development, J. Bennett Johnston, a Louisiana Democrat who is chairman of the Senate Appropriations subcommittee on energy,

and Roe agreed to the transfer.

The episode was right out of the "The Perils of Pauline." But the SSC is not out of danger by a long shot. In discussing the complex and costly research instrument, some on Capitol Hill are prone to bring up other DOE projects that have come a cropper in recent years: the Clinch River Breeder Reactor, the Brookhaven Colliding Beam Accelerator, better known as Isabelle, and Magnetic Fusion Test Facility B, now in mothballs at Lawrence Livermore Laboratory. The greatest threat to the SSC's future is the spare Federal budget and the competition for funds with other science programs and with such discretionary social programs as day-care facilities, urban housing and medical care. Then, too, it has not escaped notice in Washington that President Reagan's 1989 budget calls for giving the SSC some \$338 million more than the \$25 million it is receiving this year, while NSF would get \$333 million more in the new budget, on the way to doubling the foundation's funding by 1993. "The idea



NORTH CAROLINA This site, in rolling, mostly forested terrain near the state's northern border with Virginia, is about 10 miles north of Durham, roughly 18 miles from Research Triangle Park and some 22 miles from the Raleigh-Durham airport. The Academies committee found the site "generally favorable on environmental grounds, with no major risk to identified species or critical habitats and very little long-term impact on wetlands or water quality." However, some prime farmland would be lost and about 100 homes and businesses would be relocated. The geology is interlayered metamorphosed volcanic and sedimentary rock, which is favorable to rapid excavation. The drawbacks include the likelihood of a shear zone and the risk of modest water inflow, even though the tunnel would be 175 feet down. Proximity of major research universities and abundant scientific and technical staff makes this site attractive. Life-cycle cost estimates are slightly below average.



TENNESSEE The state proposes a generally hilly area on mostly undeveloped land near Murfreesboro, about 30 miles southeast of Nashville. The tunnel would be bored through a bed of homogeneous Ordovician limestone at an average depth of about 400 feet, well below a zone of groundwater. At that depth, rapid machine excavation could be done with minimal support and lining, but reaching the ring could pose maintenance difficulties and involve worker discomfort. Construction could be affected by heavy seasonal rains, but should have little effect on wetlands or groundwater. The site is easily accessible to the Nashville Metropolitan Airport and Vanderbilt University, as well as near new automobile assembly plants being built by General Motors and Nissan. The SSC has strong local and political support. DOE figures the area ranks among the cheapest for construction and labor, so that life-cycle costs would be slightly below the mean for all seven sites.

behind this is that the budget bonus for 'big science' and 'little science' would appear to be comparable," explains a DOE official.

Under the bipartisan budget agreement reached last November between White House and Congressional leaders, nonmilitary discretionary spending in fiscal 1989 must be held to 2% more than this year—a limitation that allows for only an additional \$3 billion (PHYSICS TODAY, April, page 55). The budget crunch enables senior members of Congress to say there is likely to be no money to start building the SSC next year.

This is the position of the House science committee's Roe and Lujan. They propose budgeting \$147.7 million for continued R&D next year and delaying the start of construction until 1990. It also seems to be the position of two of the Senate's most influential figures, Johnston and his top Republican colleague on the Senate energy committee, James A. McClure of Idaho. They expressed their view in a letter to Lawton Chiles, the Florida Democrat who is

chairman of the Senate Budget Committee, which was published on 31 March as an appendix to the committee's report on the 1989 budget resolution. Johnston and McClure say that President Reagan's budget request for \$363 million to continue the R&D program and begin procurement and construction of the SSC "is far out of line with budgetary realities." Even if Congress should agree to proceed with the SSC, their committee "doubts that the program could expand as fast as the President's request seems to assume" and holds "strong reservations about the wisdom of committing to such a massive project... in the absence of any coherent plan for supporting future research and facilities" in the physical sciences at the Energy Department.

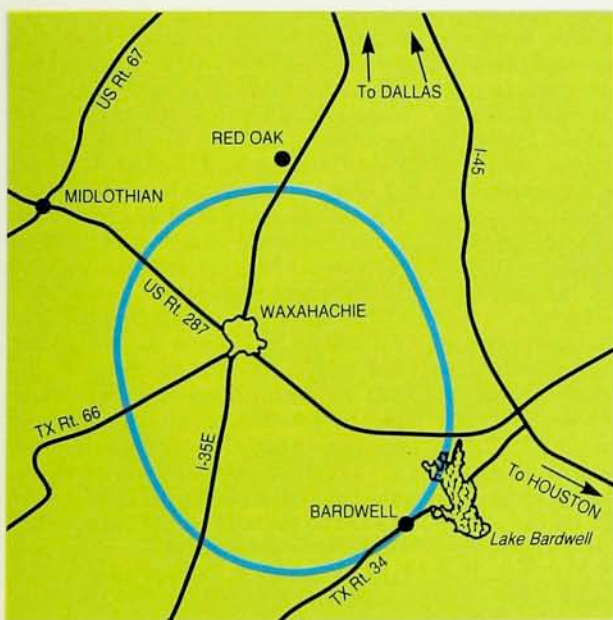
"More importantly," the senators argue, "the committee strongly opposes funding the SSC by reducing ongoing research programs in the physical sciences, fossil energy R&D and energy conservation programs." Their last word is an unobvious criticism of DOE management: "The com-

mittee recommends that major commitments to research and development and any commitment to procurement and construction for the SSC await resolution of yet unanswered questions about the source of funds for the project and its impact on future funding for research in the physical sciences."

DOE's trouble finding the best way to fund the SSC is a major sticking point. At the House science committee hearing, Roe told Salgado, "It's going to take a great deal of effort and energy on a lot of people's part to make this happen at all, as the thing is going." At a hearing a few weeks earlier before the House Appropriations subcommittee on energy, Bevill told Energy Secretary Herrington that a staff review had calculated the cost of the SSC at nearly \$9 billion once the commercial manufacture of some 9600 superconducting magnets is included in the total. Herrington disputed the higher estimate and said that foreign governments would help pay up to half the cost of the project in cash or in kind. Herrington admitted that he had no firm commitments but said that discussions had been held with government officials in Japan and Western Europe and that he was encouraged by early responses.

To help galvanize public opinion and embolden Congress to find money for the SSC, Herrington and Salgado have enlisted President Reagan to promote the project. Reagan's first media event took place before a group of 39 students from 37 states in DOE's High School Science Honors Program, assembled in the White House Rose Garden on 30 March. Before the President spoke, Steven Weinberg (University of Texas) handed him a letter from six particle physicists who have won Nobel Prizes, endorsing the SSC as representing "America's commitment to the pursuit of excellence in basic scientific research." Besides Weinberg, the signers were James Cronin (University of Chicago), Val Fitch (Princeton), Glashow, Burton Richter (Stanford Linear Accelerator Center) and Samuel C. C. Ting (MIT).

Reagan also spoke about the project on 2 April in a radio talk defending the fiscal 1989 scientific research program, which he feared "is in jeopardy because of budget constraints. . . . Some say that we can't afford it—that we're too strapped for cash. Well, leadership means making hard choices, even in an election year." He was particularly proud, he said in a Freudian slip, that "this year we'll begin work on the great grandchild of those particle accelerators that have spent—uh, meant so much to our



TEXAS Though this site includes considerable prime farmland about 30 miles southwest of Dallas and is situated reasonably close to the Dallas-Fort Worth airport, a major international airline hub, the state has a well-conceived plan to acquire the land. The Texas legislature has authorized \$1 billion to help DOE pay for the SSC. However, DOE has been forbidden by the US Congress from taking such contributions into consideration in choosing the preferred site. The Academies committee calls the geology for constructing the ring nothing short of "excellent"—chalk and marl that would enable boring machines to do surface excavations for a tunnel of high strength, requiring a minimum of support and lining. A few of the experimental halls would be 165 to 220 feet below the surface and might encounter such geological problems as heaving and slaking. The life-cycle cost estimates provided by DOE are slightly below the mean for all seven sites.

economic growth."

With such messages Reagan is making a strong pitch for the project in the final phase of his Presidency. The SSC is one of the major unfinished items of his second term. A concept even more closely identified with Reagan, the Strategic Defense Initiative, was the subject of a pep talk he delivered before a friendly audience of defense contractors and Pentagon

officials on 19 March, just four days before the fifth anniversary of his television talk launching the program. His promotions of such substantive projects as the SSC and SDI are "designed to show that the President is still fighting for his agenda," says a senior White House official. "He considers these among his most important unfinished business."

—IRWIN GOODWIN

NSF SURVEYS INDICATE SLOWER PACE FOR R&D, EVEN IN MILITARY WORK

In these uncertain economic times, the undercurrent of lab talk and conference gossip is about the availability of money for R&D. After Black Monday on Wall Street last October, economists anticipated a slowdown in corporate support of R&D, figuring that businessmen would hunker down and concentrate on products and processes already in the company pipeline. The conventional wisdom among Federal budget watchers was that government-funded R&D, already clobbered by Congress in fiscal 1988, would grow at a reduced rate for the next few years as well. The findings in two recent reports by the National Science Foundation's Science Resources Studies Division suggest that such expectations are self-fulfilling prophecies.

According to NSF, the nation's total spending on R&D is likely to reach about \$132 billion this year, which is 7% more than the estimated \$123 billion spent in 1987. Even so, the 1988 figure represents only a modest 3% increase after adjustment for the expected rate of inflation—the lowest real growth of R&D since 1977. By contrast, the real rate for all R&D expenditures by government, industrial and nonprofit institutional sources in the 1977–82 period had been 4% to 5% per year. Indeed, the increase in spending for R&D ran at 6.8% annually between 1982 and 1985 before receding to 4% in both 1986 and 1987.

NSF reckons that this year all government R&D will add up to \$65 billion, while industry will spend some \$63 billion, universities and colleges another \$2.9 billion, and independent research institutes about \$1.5 billion. About 68% of the country's total R&D money now goes into development work. While the Reagan Administration has sought to curtail nonmilitary applied research and prototype development, on the grounds that these are best left to

commercial firms, it has increased spending for defense R&D, which now accounts for about 70% of all US outlays for R&D.

According to the foundation's study team, the rise in Defense Department expenditures makes up fully 90% of the growth in Federal R&D since 1980. In fiscal 1987, which wound up last 30 September, Pentagon R&D obligations totaled \$40.7 billion, with 91% going to development. A decade earlier, DOD spent only \$11 billion on R&D, 84% of it for development work.

Outside of military circles, basic research is doing fairly well despite constraints on Federal budgets and corporate profits. In the past decade government appropriations for basic science soared by 60% in constant dollars. Spending by companies in the same period grew even faster, by a whopping 90%, following a nine-year period in which industrial outlays for basic research fell at an average annual rate of 2.3%.

The NSF survey shows that private firms expect to raise their spending in 1988 on all in-house R&D by about 3%, allowing for inflation. This rate is down from the first half of the decade, when corporations averaged 5.5% increases. The slowdown of growth in industrial R&D, which began in 1985, seems to confirm that the US economy is shifting gears as well as reacting to a reduction in the 25% tax credit on incremental R&D, which had been in effect since the passage of the Economic Recovery Tax Act in 1983.

Lowering expectations

Although some economists expect the US to enter its eighth consecutive year of business expansion around election day next November, even the most optimistic do not believe that the GNP will grow by more than a paltry 1% this year. This low expectation seems to be shared by management chiefs in 86 firms that do R&D,

including 15 of the top 20 in industrial research. In cautious responses to surveys and interviews conducted by NSF, most stated that their firms will be emphasizing development projects as prudent ways to commercialize on recent research.

It turns out, according to NSF, that the 18 firms in the surveys that had been subject to mergers, takeovers, divestitures and reorganizations in the past four years showed no increases in R&D. More than half of these companies, in fact, cut back on R&D. That should not surprise those physicists and other scientists and technicians at, for instance, the RCA David Sarnoff Research Center, which was acquired by General Electric and then spun off to SRI International, or at the Exxon and AT&T research labs.

As for the proportion of the GNP spent on R&D, the NSF study finds that this has remained virtually unchanged at 2.7% since 1985, after rising steadily from 2.1% of the GNP in 1978. The current percentage is greater than or equal to the rates of all other Western industrialized nations. But when NSF compared non-defense R&D spending with the GNP, it found that in 1983 the proportion for the US went down to 1.8%, where it has stayed ever since. During this same period the fraction of the GNP devoted to R&D increased in Japan, West Germany and France. In terms of actual investments, though, the US spends more on R&D, including basic research, than Japan, West Germany, France and the United Kingdom combined.

The entire US is expected to spend \$15 billion in 1988 on basic research, \$27 billion on applied research and \$90 billion on development. Washington provides nearly two-thirds of the money for basic research; another \$3 billion is spent by corporations, and the rest comes from such nonprofits as the Mitre Corp, Aerospace Corp and SRI International.

R&D outlays vary widely among industries. Although the 1988 estimates indicate a real increase of 10% in the machinery industry, which includes computers and robotics, they also reveal a 3% decrease in the oil industry. Among some other industries, R&D outlays after inflation are expected to increase by 5% in the aircraft industry, by 3% in professional and scientific instruments and by 3% in chemicals and pharmaceuticals. Decreases of 1% are anticipated in the electrical equipment and communications industry and in motor vehicles.

—IRWIN GOODWIN ■