

SSC: progress on magnets, uncertainty on foreign collaboration

There is little doubt that the proposed Superconducting Super Collider is the most glittering prize dangling before high-energy physicists (see page 28). The SSC would open a new frontier in the exploration of the fundamental nature of matter and energy that cannot be approached any other way. The trouble is that the machine, with protons accelerated to 20 TeV in each of two colliding beams, would be the most expensive scientific instrument ever—its cost estimated last April at \$2.7 billion to \$3 billion. Those estimates did not count the cost of the site, detectors and R&D, let alone the runup for inflation that will raise the final price tag. Indeed, Energy Secretary Donald P. Hodel cautioned his aides during his last review of the DOE budget before becoming Interior Secretary that, in testifying before Congress, they should use the figure of \$6 billion as the most likely total cost of the SSC. Not surprisingly, then, the SSC is apt to cause a massive headache for the DOE and Congress, both seeking to impose Draconian restraint on government spending in fiscal 1986 and some years after. The SSC also figures to be the object of a scramble among many states and regions that are certain its construction and operation will bring millions of dollars, thousands of jobs and uncalculated prestige to their area as a world scientific center.

Although no formal decision has been made to build the accelerator, DOE and the SSC board of overseers chosen by Universities Research Association—the consortium of 54 universities that also manages Fermilab separately from the SSC—are both proceeding on the assumption that the go-ahead will be given. "I have never seen anything in science with as many good things going for it at this stage as the SSC," says H. Guyford Stever, URA president and former science adviser to President Ford. "It's entirely possible that everything will be in place for a 'go' decision by the end of this calendar year."

Site selection. Not likely, says Alvin W. Trivelpiece, director of DOE's Office of Energy Research. The formal decision isn't expected until late next year

at the earliest. Even so, Trivelpiece has taken several steps in anticipation of judgment day. On 30 November he wrote to Frank Press, president of the National Academy of Sciences, and Robert M. White, president of the National Academy of Engineering, for assistance in the site-selection process. Under the plan outlined by Trivelpiece, a study of criteria for the SSC site is already under way for DOE by the Central Design Group, led by Maury Tigner, of Cornell. While some of the questions about the site will be determined by the circumference of the main beam ring, there are other concerns in setting criteria—physical topography, geological structure, transportation facilities, and proximity to major universities, an abundant power supply and a pool of talented people to work at the accelerator center.

"I suspect that dozens of states will bid for the SSC and that some states will form regional groups to press their case," says Stever. "The tactics that some universities are now using on Congress to fund new science buildings will seem insignificant compared to what's likely to happen when DOE asks for bids on the SSC."

When the "200-BeV" machine was planned in the early 1960s, there were 126 proposals involving more than 200 localities in 46 states vying for it. The final shootout involved a half-dozen recommended by a blue-ribbon panel of the National Academy of Sciences. There are two versions of how Fermilab came to be the final choice. One has the old Atomic Energy Commission making the decision "strictly on the strengths of the Fermilab's case," according to Gerald Tape, a commissioner at the time. The other account attributes the success of Illinois to the political skills of Senator Everett M. Dirksen, who won for his state in a tradeoff over a critical foreign policy vote needed by President Lyndon B. Johnson.

Orderly process. In hope of avoiding a political stampede for the SSC, Trivelpiece plans to issue the site criteria along with a DOE Request for Proposals (known in Washington bureaucratese as an "RFP"). When the various

contenders respond, the proposals will be screened by DOE to make sure the minimum criteria have been met. The acceptable proposals then will be evaluated by the NAS-NAE panel of some 15 distinguished people with "appropriate experience," says Trivelpiece. The panel would identify a tiny number of applications, possibly no more than three or four, unranked but with some analysis of their strengths and weaknesses based on the given criteria, so that DOE can make the final choice.

The reason for establishing this procedure "is the intense interest in the possible location of the SSC," Trivelpiece explained in a memorandum to Hodel. "In the absence of a clear statement of the department's plans, some of the interested parties may attempt to influence the choice of a location prematurely." Therefore, wrote Trivelpiece, "it is important to establish the site-selection procedure now, well in advance of when it might be needed to help ensure an orderly... process and fair treatment for all interested parties."

Though DOE's decision is still a year or two off, the battle for the SSC has already begun. In Illinois, Governor James Thompson has spent \$500 000 on geological site surveys and, according to his own press announcements, is preparing to spend as much as \$7.5 million more in a vigorous campaign to woo and win the facility. In Illinois's favor is the presence of Fermilab, which would provide a proton injector, laboratory facilities and trained staff to keep costs down substantially. Arizona has proposed a site near the Kitt Peak Observatory, and New Mexico has offered land near Albuquerque. Similarly, Utah has hired an engineering firm to make geotechnical surveys in the expanse of the Great Salt Desert and on US land at the Dugway Proving Grounds and Wendover Air Force Base. Despite its high water table, Florida insists the SSC can be built there. Idaho has expressed keen interest, with support coming from James A. McClure, chairman of the Senate Energy and Natural Resources Committee, which oversees DOE's activities and budgets, and a freshman member of

Congress, Richard Stallings, who sits on the House Science and Technology Committee. Stallings argues for a site near DOE's reactor test station at Arco, where there is ample electrical power and a large airport. Other interested states include Colorado, Michigan, Minnesota and Wisconsin.

Lone Star claim. Texas, to nobody's surprise, has staked a powerful claim. Its campaign was launched more than a year ago under the command of Governor Mark White, who has approached DOE and rallied members of Congress and local businessmen to do whatever is necessary, including spending state funds and offering real estate, to gain the SSC. A site-selection team appointed by White has been looking at locations around Houston, Austin, Dallas and San Antonio.

What's more, research on one type of superconducting magnet for the SSC is going on at the Texas Accelerator Center under a design team headed by Peter M. McIntyre of Texas A&M and F. Russell Huson (formerly at Fermilab). DOE gave the team \$4 million the first year to perform R&D on 3-tesla superferric magnets, and four Texas universities have put up another \$2.3 million for the work. McIntyre is enthusiastic about his group's progress. Two 3-foot prototype magnets have been tested successfully at Brookhaven, reaching full field strength without quenching. The Texas magnet is built straight but can be bent like a "wet noodle" over its length, says McIntyre. Tooling has been completed for a 25-foot model, states McIntyre, and if all goes according to plan, magnets 100 feet long can be manufactured in quantity. General Dynamics has been working with the Texas team to do just that.

The 3-tesla magnet was one of three superconducting magnets considered in the SSC Reference Design Study approved by DOE last August (PHYSICS TODAY, October, page 21). The others were a 5-tesla magnet based on Fermilab's Tevatron magnets and a 6.5-tesla design to be developed by Brookhaven and Lawrence Berkeley labs. More recently, all three labs have decided to combine the two high-field designs into one magnet of 6 tesla.

Magnet concepts. It turns out, actually, that five different magnet types are now undergoing engineering and modeling studies. According to present plans, one of these will be selected sometime in late summer for final development. The five concepts include three magnets with conductor-dominated $\cos\theta$ geometries in their coils and two iron-dominated superferric variants. Of the $\cos\theta$ types, all intended to operate at 6 tesla, one is a cold-iron, magnetically linked magnet with two beam channels in one struc-



First two superferric magnets developed at the Texas Accelerator Center are displayed here by (left to right): R. Stegman, R. Wolgast, R. Huson, J. Zeigler, H. Hinterberger and J. Colvin. In the SSC, these magnets, each 140 meters long, would be mounted one above the other, carrying the colliding beams in opposite directions.

ture; another is a single-channel cold-iron version; the third is an ironless type. All would use similar collared-coil assemblies. Brookhaven and Lawrence Berkeley are at work on the 2-in-1 design, and a consortium of all three laboratories is developing the 1-in-1 cold-iron version. Fermilab is continuing work on the ironless magnet. At the Texas Accelerator Center, meanwhile, 3-tesla, 2-in-1, cryogenically linked and cryogenically independent magnets are under study. Prototypes of all but the cryogenically independent, 3-tesla design have been built and tested, and improved versions are now being assembled.

For fiscal 1985, which began last October, DOE has provided \$20 million for SSC R&D. Of this total, Brookhaven will receive \$5 million, Fermilab \$3.9 million, Lawrence Berkeley \$0.8 million, the Texas Accelerator Center \$5 million and the Central Design Group \$5.3 million. In addition, DOE has allocated \$1.7 million to Brookhaven, \$2.1 million to Fermilab and \$1.2 million to Lawrence Berkeley for R&D of direct benefit to the SSC. Though the SSC board of overseers, under the chairmanship of Boyce D. McDaniel of Cornell, proposed that the SSC program should be doubled to \$40 million in fiscal 1986, the DOE budget calls for a "freeze" at \$20 million for the fiscal year that begins next 1 October. McDaniel and Tigner suggest that the funding limits may slow down magnet development, particularly when industry has expressed interest in joining in, provided Federal funds are available.

Funding R&D for the SSC is only one of the uncertainties the machine faces.

Energy Secretary Hodel, a staunch supporter of the SSC since his department's High-Energy Physics Advisory Panel first recommended it in July 1983, was chosen by President Reagan just after Inauguration Day to be Interior Secretary. In the musical chairs taking place at the top, the new Energy Secretary is John S. Herrington, who served as Reagan's personnel director during the first term. A change of leadership in a department often has a somewhat chilling effect on exotic programs—and the SSC would be clearly foreign to the new secretary. Moreover, Reagan is reported to have directed Hodel and Herrington to study options for "managing more efficiently" the functions now handled by Energy and Interior, which Washington observers interpret to mean reviving the dormant ideas of dismantling Energy or merging it with another agency. Another imponderable is that some scientists outside the high-energy physics field have taken to the barricades to attack the funding that SSC requires.

One sure way of reducing some uncertainties, particularly those that are fiscal and symbolic, is to muster public support and international collaboration for the SSC (see box). To generate wider enthusiasm beyond the community of some 2000 high-energy physicists, URA proposes to appoint a few leading industrialists to the SSC board of overseers. "We have in mind," says Stever, "some really big wheels."

Seeking collaborators. To find international collaborators, Trivelpiece and the President's top scientist, George A. Keyworth II, have met with their European and Japanese counterparts

to discuss preliminary planning and cost sharing of the machine. So far, no commitments have been forthcoming. Given the bleak realities of government balance-sheets these days, Europe and Japan may be overextended already in Big Science facilities. CERN is committed to completing its Large Electron-Positron Project in 1989, and West Germany is scheduled to finish another large accelerator, HERA, at Hamburg in 1990, by which time construction of the SSC would be well under way, according to current plans. Japan, however, is another story. The Japanese will be paying for TRISTAN through 1986. Moreover, they have extensive experience with superconducting magnets and an abiding commitment to upgrading their high-energy physics. Keyworth and Trivelpiece consider Japan the most likely collaborator in the SSC.

CERN alternative. When CERN director Herwig Schopper argued the case for a proton-proton Large Hadron Collider as a more "cost-effective alternative" to the SSC before the International Committee on Future Accelerators, which met in Japan last May, the idea, though not new, was recognized as a direct threat to the SSC. Schopper, backed by CERN's Carlo Rubbia and Giorgio Brianti, claimed the world would be better off going their way, using still-to-be-developed magnets of 9 or 10 tesla in a collider ring to be placed atop the still-to-be-completed LEP beam ring (PHYSICS TODAY, June, page 17). But CERN hadn't reckoned on a European political movement toward greater cooperation in international scientific R&D. After France's President François Mitterrand strongly urged the other six heads of state at the Versailles Summit Conference in 1982 to collaborate in scientific research and technological development for the "revitalization and growth of the world economy," the idea of joining forces grew. It acquired additional cachet at the Williamsburg Summit in 1983 when a Working Group on Technology, Growth and Employment was formed. The group identified high-energy physics as one of 18 subjects, from aquaculture to solar system exploration, that would benefit from collaboration.

In a paper that Working Group leaders, who call themselves "sherpas," carried to the London Summit last May, there was a telling statement: "It is neither sensible nor necessary for science R&D to be developed purely on a national basis. Science itself is, and always has been, international in nature.... Science is now inextricably linked to technology and hence to economic and social progress.... To meet the needs for international cooperation in science and technology, governments should... seek cooperation

Keyworth sees SSC 'a magnet for talent and creativity'

The Superconducting Super Collider was one of the main topics for President Reagan's science adviser, George A. Keyworth II, in his defense of the proposed budget for science research in fiscal 1986 before the House Committee on Science and Technology on 5 February. By turns he was confident, forceful and unyielding in his remarks.

"I won't conceal my opinion," he said, reading from a prepared statement, "that it would be a serious blow to US scientific leadership" if the SSC were built anywhere but this country. The facility would be "a magnet for talent and creativity," he observed. "Such an accelerator 'involves far, far more than the relatively small number of people who can work directly with it, because it stimulates interest in science and excellence far across society and because it inevitably spins off new ideas and technologies.'"

For the next several years, Fermilab's Tevatron and the Stanford Linear Accelerator place the US "in a strong position to maintain our leadership in fundamental particle physics," said Keyworth. "But we're on notice that over the long haul, leadership in high-energy physics is up for grabs. The recent, stunning success of a European team working at CERN in Switzerland in detecting the Z^0 particle was the most important advance in a decade, and it quickly brought the Nobel prize to the team's leaders. That's a very real reminder that our many years of leadership in that field are, right now, being aggressively challenged."

Opening the question period, Representative Don Fuqua of Florida, the committee chairman, asked if Keyworth thought the entire science community could be brought around to rally behind the SSC. Commitment to the SSC by scientists "and the nation as a whole" is "essential," Keyworth replied. He estimated the total cost of the project when built and operational by 1993 or 1994 at some \$5 billion to \$6 billion—"an unprecedented large sum for an experimental facility in a single area of science."

The SSC, he continued, "presents a unique challenge, and I think the biologists, the chemists, as well as the public have got to join with us in making the decision: Do we want to give up clear leadership and resign ourselves to... second place in a field where we have long been unquestioned leaders?" Deciding to proceed with the machine "is a measure of the importance we place on excellence, on attracting our top young minds to the most creative endeavors we can pursue," he said, "because I think traditionally no field has been more attractive in the sense of pure creativity than elementary-particle physics. I also think the field has never been more exciting. I think we stand toward the end of this century to make the same kinds of contribution that James Clerk Maxwell made at the end of the 19th century in developing the law combining the electric and magnetic fields. I think it is monumentally important.... I think the other communities in science not only can but must be brought on board in support of the SSC for its symbolism of excellence and creativity."

The high cost of the SSC in these fiscal hard times, Fuqua wondered aloud, might mean some kind of international collaboration. "It is essential," Keyworth asserted, "because we must realize there will not be two of these machines. We've reached a point in time and sophistication where we can no longer continue to explore parallel paths with Europe or Japan or even the Soviet Union... duplicating these massive facilities.... This should be a truly international project."

Representative George E. Brown Jr. of California reminded Keyworth that particle physics and the biotechnology revolution would be competing simultaneously for government funds in the next decade. The issue of Federal support has been joined by the increasing competitiveness in science, said Keyworth. As the chief spokesman for the Administration's R&D policies, Keyworth admitted he will have to allay anxieties about the machine. Accordingly, he planned a campaign of public persuasion through the news media to win support for the SSC and for scientific research in general. The message, according to Keyworth, is that science research is basic to maintaining economic growth and strengthening military security.

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in, and in certain cases joint operation of, large scientific research installations, the cost of which is prohibitive for a single government but which are nonetheless indispensable for the advancement of science."

Regional facilities. In preparation for the Bonn Summit this May, Trivelpiece, as leader of the high-energy-physics working group, appointed a subpanel to identify the most important major research facilities anywhere. Meeting in Abington, England, last November, the panel, headed by Harry Atkinson of Britain's Science and Engineering Research Council, concluded a lively debate on new facilities by calling for regional machines, and refused to accept the concept of a single world machine.

The panel said it seemed possible to build and operate a new generation of high-energy physics facilities "within broadly constant budgets... provided that there is no duplication of major facilities. This implies that we plan on an inter-regional basis to ensure complementarity and cost-effective decision-making. Further concentration is probably inevitable; however, we are convinced that more than one region working effectively in high-energy physics is essential to the health of the science...." Later in the report, the panel listed various proposed machines, including the SSC and the options for the LEP tunnel, but claimed "it is too early to select a strategy which will satisfy scientific needs in the most cost-effective manner." The US

member of the panel, Yale's Jack Sandweiss, who also heads the High-Energy Physics Advisory Panel, recalls that some Europeans at the Abington meeting supported the SSC but could

not bring themselves to admit that CERN should be second to the US in particle accelerators. Europe, it seems, wants to keep its options open, awaiting the US decision on the SSC.—IG

At last, chips get copyright protection

At a small ceremony in the Library of Congress Copyright Office on 7 January, Intel Corporation registered the first integrated circuit for copyright under P.L. 98-620, the Semiconductor Chip Protection Act of 1984, signed by President Reagan on 8 November. Intel's 27C256 is an erasable, programmable read-only memory chip with 256 000 binary digits of memory. With its electronic circuits intricately etched on 15 mask overlays, 27C256 is a new kind of intellectual property that Congress decided, after six years of wrangling, ought to be protected from illicit copying both at home and abroad. Minutes after Intel received its copyright, Motorola registered its MC68020 HCMOS (for highly complementary magnetic oxide silicon) microprocessor, capable of executing 2.5 million instructions per second, and Harris Corporation a 64 000-bit read-only memory.

Semiconductor chips have been in legal limbo between the traditional patent and copyright laws. Chips were not entitled to copyright protection, lawyers argued, because they are not written like song, plays or books, and thus cannot be considered works of art. Moreover, they cannot qualify for patenting, because chips do not represent a wholly new invention or concept, such as the transistor, which is the main component of semiconductor

chips. So instead of bending the existing laws around a new technology or revising the copyright law that was last rewritten in 1976, Congress enacted protection for the design and layout of the circuits as well as for the photographic masks used to etch the layouts into chips. The legislation represents the first expansion of the legal protection of intellectual property in the US in more than 100 years.

Piracy has become a serious threat to the companies that are the most advanced in semiconductors. US manufacturers invest heavily in improved chips, only to find competitors disassembling the mask works—the term is “reverse engineering”—and marketing copies that can be sold more cheaply because the pirates bear none of the R&D costs. R&D for a chip as complex as Intel's new 256K EPROM can run as high as \$50 million. The cost of duplicating such a chip is often less than \$50,000.

Sui generis. Copies of advanced chips by US semiconductor manufacturers, Representative Ed Zschau of California's Silicon Valley told his colleagues during a House debate last June, threaten to knock off a big hunk of the industry's total sales, amounting to about \$100 billion last year. As a case in point, Zschau spoke of the Z-80 microprocessor developed by Zilog, a

company in his district, that had been copied and sold by a pirate firm in Japan at half the price of the US chip. Within months after the copy was introduced, Zilog lost 50% of the market and more than \$10 million. “Such losses are hardly an incentive for innovating,” said Zschau.

P.L. 98-620 provides a wholly new part—Chapter 9—of Title 17 (the copyright section) of the US Code, specially for chips. It recognizes that, distinct from the author's or artist's copyright for a new work or the inventor's patent for a new product, the particular layout of a chip is *sui generis*—unique intellectual property and, as such, fully entitled to protection. The new law makes it illegal to reproduce any semiconductor design for 10 years after registration and carries penalties of up to \$250 000. It is this protection that the chip makers sought through their Congressmen.

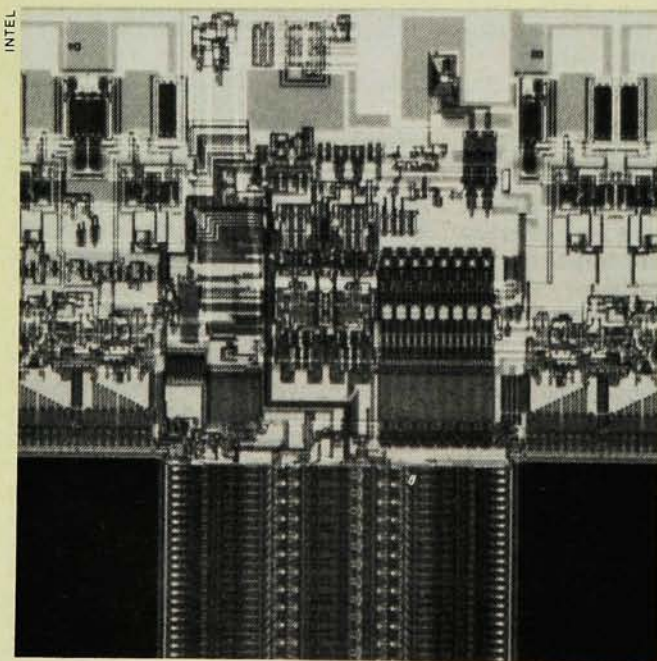
Japanese backing. The legislation was also supported by Akio Morita, chairman of Sony and president of the Electronics Industries Association of Japan, who called it “highly desirable, both of itself and as an indication of the proper direction for the international protection of such intellectual property.” In a letter to Representative Robert W. Kastenmeier of Wisconsin, chairman of the House Subcommittee on Courts, Civil Liberties and the Administration of Justice, which has copyright jurisdiction, Morita wrote:

Both governments should recognize that some form of protection to semiconductor producers for their intellectual property is desirable to provide the necessary incentives for them to develop new semiconductor products. And both governments should take their own appropriate steps to discourage the unfair copying of semiconductor products and the manufacturing and distribution of the unfairly copied products.

With the backing of Morita and Japan's Ministry of International Trade and Industry, legislation similar to P.L. 98-620 will be submitted to the Diet in March.

During hearings on the chip legislation in Congress last year, US Patents and Trademarks Commissioner Gerald J. Mossinghoff had opposed protecting foreign manufacturers, especially the Japanese, until they enacted similar laws. As it stands, the US law contains an international transition provision that enables foreign firms to obtain mask work protection in the US if their country is moving toward protecting chip designs at home or has already enacted such laws, and if their citizens or “persons controlled by them” are not engaged in pirating chips in the marketplace.

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Memory chip. Detail of Intel's recently copyrighted 27C256 EPROM is enlarged some 23 times. The chip itself is 10 mm on a side; the photo shows a central 3.6-mm portion.