further consideration of Ting's cost estimate and his management style. (See the box at right.) The EMPACT design, always a long shot in the competition, lost out mainly because of its unconventional technology.

Other signs of progress are clear. On 1 February, Watkins signed the Record of Decision, the final step in the prolonged process for approval of the SSC's Environmental Impact Statement, thereby enabling the State of Texas to acquire all of the 17 000 acres of rangeland, cotton fields and prairie allocated for the SSC site around Waxahachie, about 25 miles south of Dallas. The DOE inspector general's report had been critical of the slow pace of land acquisition.

The report also stated that "the critical path of the SSC program, and the most expensive and complex part, is the research and development, acquisition, testing and successful installation and operation of the SSC's 12 000 superconducting magnets. These will require as much steel as a battleship and enough superconducting wire to circle the equator 25 times." The magnets that will bend the countercirculating beams of protons are estimated to cost about $2 billion, twice the figure given in 1987. "Performance standards for the magnets are extremely high," said the report, "so that the failure of a single magnet will stop operation of the SSC until it is fixed." The inspector general urged speeding up the magnet development program.

The lab has chosen General Dynamics as the "lead industrial partner" and Westinghouse Electric as the "follower" to initiate high-volume manufacture of the superconducting dipole magnets. It also has selected seven companies to vie for supplying superconducting cable for the magnets. Through successive claddings and extrusions, the firms will produce wire strands slightly fatter than a human hair, consisting of 7000 filaments of titanium alloy in a matrix of copper. Fabricated into cable and chilled to 4.3 K, each of the strands will carry an electric current equal to the output of some five car batteries. The SSC will use 4000 tons of cable.

Once the new design requirements were set, four dipole test magnets, each about 1.5 m long, were built and operated at Brookhaven, at Fermilab and at KEK in Tsukuba, Japan. All four test magnets were short versions of the 15-m superconducting dipole. In its statement about the tests, issued in February, the SSC lab declared, "The speed with which design improvements were brought to an initial and successful test was a reminder of how mature the technology has become since J. E. Kunzler's pathbreaking niobium–tin solenoid raised the promise in 1961 of applying superconductivity to the design and manufacture of accelerator magnets."

A critical measure of the performance of a superconducting magnet is the maximum current it can sustain without "quenching"—that is to say, losing its superconducting properties. Once the magnet has been "trained," quenching should always occur at the same current for a given operating temperature. Initial training quenches can occur at lower currents as magnet coils or filaments settle into place. But once the coils are trained, the quench current should remain constant over repeated cycles of cooling down and powering up.

Another measure of a magnet's performance is the safety margin between its required operating current and the quench current. Dipole magnets built to the old design with a 4-cm bore operated during tests with about a 5% margin, quenching at 6800 A at a temperature of 4.3 K. This margin was considered adequate for the early stage of development. Lab staff thought a 10% margin seemed achievable with improved cable wire and other magnet changes. Magnets built to the new design employ a wider bore and cable with 30 strands rather than 23 in the inner layer and 36 strands instead of 30 in the outer layer, increasing the width of each cable by some 25%.

A Proposed Detector for the SSC Is Approved

The Solenoidal Detector Collaboration's "Letter of Intent," which received the blessing of the SSC Laboratory's Program Advisory Committee in December, envisions a detector 40 meters long and 23 meters high, looking somewhat like an octagonal barrel lying on its side. The cost of the 30-kiloton SDC detector is estimated at about $500 million.

The SDC is a collaboration of 61 institutions, headed by George Trilling (Lawrence Berkeley Lab), seeking to build a general purpose detector that will be fully functional at the accelerator's design luminosity of $10^{33}\,cm^{-2}sec^{-1}$, but which could also do specialized investigations at higher luminosity. The detector is designed to study electroweak symmetry breaking and the top quark; to search for supersymmetric particles, new gauge bosons and evidence for substructure within quarks; and, most important of all, to uncover the totally unexpected.

The detector's central tracking system, 4 meters in diameter, is to be surrounded by a superconducting solenoid magnet that provides a 2-tesla field. Its innermost precincts will house pixel silicon detectors and an array of silicon strip detectors. Beyond 50 cm from the beam axis, tracking will be done either by wire drift chambers or scintillating fibers, or by a combination of both. Several other subsystems of the SDC detector also involve choices yet to be made. The central calorimeter, for example, which is to surround the magnet, will have either scintillating tiles or liquid argon interspersed between its absorbing metal sheets.

Out beyond the iron return yoke of the solenoid magnet will be the muon system. Inner and outer muon tracking chambers are to be separated by a 1.5-meter-thick cylinder of iron magnetized by toroidal windings, which bends the muons again to augment the momentum measurement provided by the central tracking chamber. Additional calorimeters, tracking chambers and Čerenkov counters in the two end caps will provide the SDC detector with its essentially "hermetic" 4π view of almost everything that comes out of the 40-TeV proton–proton collisions at its center.

The detector's greatest challenge is that it, and its attendant computers, will have to make some sense of about 10^8 collisions per second, each one producing hundreds of charged and neutral particles.

The other two detector systems considered at the Program Advisory Committee's December meeting—L* and EMPACT/Texas—were more specialized than the general purpose SDC. Both put particular emphasis on the detection and precise measurement of muons. The EMPACT/Texas scheme went so far as to eschew any magnetic field in its central tracking chamber. Muons were to be bent by an air-core superconducting toroidal magnet out beyond the calorimeters that absorb all the hadrons and electrons. The L* proposal is characterized by the enormous magnetic volume of its solenoid—19 meters in diameter and filled mostly with precision muon tracking chambers.

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