Stanford Linear Collider funded

From the late 1950s to the early 1970s it seemed that the United States and Western Europe (and to some extent the Soviet Union) were in a race to build new accelerators for particle physics, to see who would be the first to build a new design or reach a new high in energy. Then in the late 1970s American accelerator building went into budgetary doldrums and fell behind Western Europe.

The latest news is that the race is on again. The July/August CERN COURIER, organ of the West European international laboratory CERN in Geneva, announces that the French government has signed the *Déclaration d'Utilité Publique* (Declaration of Public Utility) for the laboratory's Large Electron-Positron collider (LEP). The declaration is the legal permission for construction to begin. At about the same time President Reagan signed the appropriations bill for fiscal 1984 for the U.S. Department of Energy, which contains $32 million dollars to begin construction of the Stanford Linear Collider (SLC) at the Stanford Linear Accelerator Center (SLAC) in Palo Alto, Calif.

Both machines are designed to accelerate beams of electrons and positrons to energies of 50 billion electron-volts (50 GeV) each and collide them head-on. This energy range seems most appropriate for investigating the consequences of the recently developed unified theory of two of the four varieties of force in nature, electromagnetism and the weak subatomic force. This theory is part of an effort to find a comprehensive unified theory of all of physics.

While LEP is a more or less conventional storage ring (SN: 1/20/79, p. 42), the SLC is a new design that will take electrons and positrons accelerated in SLAC's existing four-kilometer-long linear accelerator, bend them to the left and right around curved arms and bring them together head-on. Burton Richter, technical director of SLAC, who is largely credited with originating and pushing the idea of the SLC, sees it as the prototype of a new kind of electron-positron apparatus. If the SLC proves out, he hopes to see much more energetic versions built, into the trillions of electron-volts (TeV).

Oct. 1, 1983, the beginning of fiscal 1984, is the first day the appropriated money can be spent, and the SLAC people want to be able to turn the first shovel that day. CERN COURIER says LEP construction should start soon, and first operation would then be expected in the second half of 1988. Richter expects the SLC to be ready in 1986. The three-year schedule depends on Congress appropriating enough money in the next two years to keep construction going at the optimum rate. Richter's estimate of the total cost is $112 million. Work to be done on the SLC includes a small increase in the maximum energy of the existing linear accelerator, construction of the curving arms and the collision point, and construction of two small storage rings that will be used to narrow down the beams.

Narrowness of the beams, according to Richter, is why linear colliders become attractive at this energy level. The idea, he says, was first mooted 15 years ago. But at the energies physicists wanted then, a linear collider would have given beams much too wide to insure a high enough rate of actual collisions when a bunch of electrons was thrown at a bunch of positrons. But as the beams are accelerated to higher and higher energies, they narrow themselves naturally by a process called adiabatic damping. At the energies proposed for the SLC they become narrow enough not only to be useful but to provide what Richter and others see as a significant advantage.

Actually the beams don't become quite narrow enough by adiabatic damping alone. The two auxiliary storage rings, which will connect to the linear accelerator about a quarter of the way down its length, will help by narrowing the beams further through radiative damping, that is, by emission of synchrotron radiation.

Richter starts his description of the SLC's cycle in those damping rings, where, at the start of a cycle, two bunches of electrons and two of positrons will be circulating. Both bunches of electrons and one of positrons will be taken out for acceleration in the linear accelerator. At the end of the linear accelerator the bunches will have energies of 51 GeV. Somewhat before this point, one electron bunch will be picked off and sent against a target to make positrons. The other electron bunch and the positron bunch will go around opposite arms of the curved section (losing some energy to synchrotron radiation on the way) and come together at 50 GeV each. Meanwhile the positron bunch made by the first electron bunch will be carried in a separate tube back to the beginning of the linear accelerator, where it will be joined by two new pulses of electrons provided by an electron gun, and go to the damping rings.

The bunches start out with a lateral width of 500 micrometers (half a millimeter). The combination of radiative and adiabatic damping brings them down to 30 micrometers, and then focussing magnets get them to 1.4 micrometers. This means, Richter says, that the vacuum tube in which the collisions take place could be no thicker than a pencil. At a storage ring it would have to be 10 centimeters thick. This provides an important experimental advantage, Richter says, and he is seconded by Abraham Seiden, director of the Santa Cruz Institute for Particle Physics (SCIPP) at the University of California at Santa Cruz: Detectors can get very close to the interaction to pick up the tracks of extremely short-lived particles that may be produced there. Seiden is one of the leaders of a group from SCIPP, California Institute of Technology, the University of California at Berkeley, Stanford, and the Universities of Michigan and Hawaii, that is building the first detector for the SLC, Mark II.

Another advantage over storage rings, Richter and Seiden say, is that the SLC produces polarized electrons, which storage rings do not. With polarized electrons experimenters can better see the effects of left-handedness or right-handedness. The particles involved in the physics the SLC will first do, which is the physics of the Z^0 particle, all have a certain handedness, and the effects of left-right symmetry or asymmetry (technically called parity) are very important. The Mark II group had hoped to be the discoverers of the Z^0, but an experiment at CERN beat them to it.

Z^0s, which ought to be produced in the electron-positron collisions, are expected to decay either into electrons and positrons, pairs of muons or pairs of tau particles, or perhaps pairs of something else, currently unknown heavier members of this series (collectively known as leptons). The Z^0 is a kind of crown jewel of the now partially unified theory of particle physics. It, the two W particles (SN: 2/5/83, p. 84) and the photon are the mediators or embodiment of the electromagnetic and weak subatomic forces concerned in the theory. That the Z^0, with a mass of almost 100 GeV, can be paired in this way with the photon (mass 0) is a large *asymmetry* in a theory based on symmetry. Theoretically, this break in the symmetry is made possible by the existence of the so-called Higgs particles. Mark II will try to find out whether Higgs particles really exist and if so whether they are elemental particles or composites of something. Z^0s could also produce new varieties of quarks.

Many of the things sought may manifest themselves very close to the electron-positron collision point, and the most innovative part of Mark II will be a vertex detector to lie close around that point. Seiden says three designs are under consideration including two kinds of solid detectors and a more intense version of the familiar streamer chamber.

A streamer chamber is a tank of gas crisscrossed by thousands of wires. Electrically charged particles going through it leave a trail of ionized gas atoms, and the wires serve to locate those trails. A large streamer chamber, three meters in diameter and 2.4 meters long will be the main part of Mark II. There will also be lead shower counters to record photons. Thus, says Seiden, Mark II will record all charged particles and photons. The presence of neutrinos will have to be inferred. Mark II should be ready before the SLC. It will operate at the existing PEP storage rings until the SLC is finished. —*D. E. Thomsen*