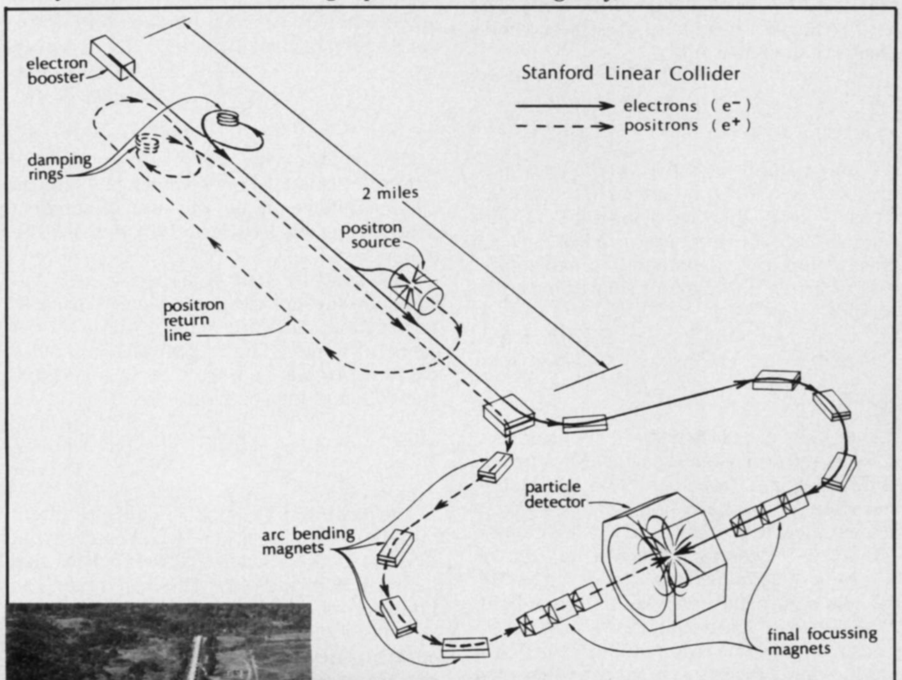
Missing collisions: Troubles at the SLC

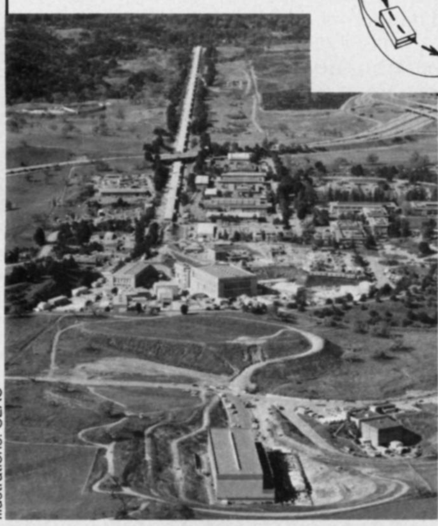
Designed to slam together opposing beams of electrons and positrons, the Stanford Linear Collider is the first of a new generation of sophisticated, high-energy machines for probing the structure of matter. Out of the particle spray created in such collisions, physicists hope to obtain a more detailed picture of the interactions between subatomic particles.

The collider, located at the Stanford Linear Accelerator Center (SLAC) at Stanford University, consists of two main parts: a 22-year-old, extensively modified, 2-mile-long linear accelerator and a newly built section, resembling a pair of pincers at the end of a long, thin handle, carrying electrons and positrons along opposing arcs to the collision point (see diagram). Physicists chose this innovative design to keep down the cost of the new $115 million accelerator and to demonstrate the feasibility of such a scheme for accelerating and colliding particles at high energies.

Getting the machine to work reliably has proved an exacting task – somewhat like firing two guns at each other and expecting the bullets to hit even when the guns are 100 miles apart. In the accelerator, the magnetically guided and focused electron and positron beams, racing at nearly the speed of light, are squeezed down to less than the width of a human hair before the particles collide. Last April, SLAC researchers for the first time managed to bring the beams into collision, proving the design works in principle. At that time, they had high hopes of getting down to the business of collecting data after a few more months of technical refinements.

During July, however, the beams were in collision only 6 percent of the time the collider operated, and researchers obtained less than 21 hours of meaningful data. "Those numbers are highly unsatisfactory," says SLAC spokesman Michael Riordan. "We'd like it to work much more reliably."





Illustrations: SLAC

A schematic diagram (above) and an aerial view (left) of the Stanford Linear Collider.

Last month, SLAC Director Burton Richter appointed a special task force of experts to take charge of bringing the collider up to par. Richter himself is spending half of his time away from his administrative duties to work on the day-to-day operation of the accelerator. Machine time during weekends is still used for collecting data, but weekdays are devoted entirely to studying and fixing collider problems.

Many of the difficulties stem from the decision to build the new collider piggybacked on an older machine not originally designed to handle such narrow particle beams. A recent heat wave exacerbated equipment problems by overheating the above-ground shed containing microwave generators, used for accelerating the electrons and positrons, and other electronic equipment. With no air conditioning in the equipment shed, temperatures in excess of 100°F caused failures in computer chips, power supplies and switches. Furthermore, the accelerator's cooling system works well only up to 95°F. At higher temperatures, the 2-mile-long copper tube at the heart of the linear accelerator begins to warm and expand, causing other problems.

"This is the most difficult period of the year to run the entire accelerator," Riordan says. "We're trying to bring up what is perhaps one of the world's most complex prototypes in the wrong season."

Collider startup was also delayed last year when machine operators discovered the electron and positron beams widened rather than narrowed as they passed through the collider's curved sections. That problem was traced to the geometry of the underground arms, which, to reduce excavation costs, follow the undulations of the local landscape instead having a level floor. The problem was solved by individually adjusting the position and orientation of more than half of the nearly 500 magnets along the beam paths.

These delays have reduced the lead the SLAC group has over researchers at CERN, the European Laboratory for Particle Physics near Geneva, Switzerland. The European group is building a more conventional but gigantic circular accelerator, at a cost of more than $1 billion. In that electron-positron collider, expected to be ready by late 1989, two particle beams constantly circulate in opposite directions within a ring 17 miles in circumference.

Both the Stanford and CERN groups hope to use their new high-energy accelerators to create large numbers of Z° particles, carriers of the weak nuclear force responsible for radioactivity and certain types of slow particle decays. First discovered in 1983 at a CERN accelerator, the Z° particle has since been detected only rarely. By creating thousands of such particles, physicists can determine precise values for the lifetime and mass of this particle and work out the manner in which the Z° decays into other particles.

So far, no Z° particles have been detected in the Stanford collider. Richter and his colleagues hope to get the machine operating reliably by February of next year, when several key experiments are scheduled to begin.

"The problems are serious," Riordan says. "The major technological breakthroughs have occurred. What we're dealing with is getting the entire system to work at a reliable level. We have to make the orchestra play together better."

– I. Peterson