# BEAMS IN PEP

### Through the golden hills of California now come 19-GeV electrons to meet 19-GeV positrons

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Photos: Stanford Univ.

*This view of the colliding beam underground shows bending magnets in PEP's tunnel.*

It is hard to imagine the physics of the last few years without colliding beams of electrons and positrons. It is much harder for physicists to imagine the physics of the coming years without them. Yet experiments that depend on electron-positron collisions are likely to be done in only two laboratories in the world — the DESY laboratory in Hamburg and the Stanford Linear Accelerator Center on the Peninsula south of San Francisco. The Positron-Electron Project at Stanford is now physically complete, and beams are being introduced into its ring.

When PEP begins actual experimentation around the beginning of 1980, the world will have two sets of apparatus that can collide beams of electrons with beams of positrons in the energy range that is now the highest possible: from 5 billion electron-volts (5 GeV) per beam to 19 GeV per beam or thereabouts. What happens after such high energy electrons collide with such high energy positrons and annihilate each other is where the physics fun is. DESY's counterpart to PEP, the installation called PETRA, has been operating since the end of 1978. It has already contributed a couple of significant results and a certain amount of controversy to the liveliness of physics.

The DESY people are many things, but one of the things they are is speed merchants. They built their PETRA in record time, got it operating immediately, and since then they have wrung every advantage — their critics would say too much advantage — out of every result it has yielded. One such wringing (SN: 9/1/79, p. 151; 10/20/79, p. 266) was done with the cooperation of, almost at the request of, some of the very American physicists who have griped the hardest about the "high-powered DESY publicity machine." (Incidentally, the DESY people liked that phrase so much that Science News has received press releases on which some hand has written "from the high-powered DESY publicity machine.")

PEP was planned before PETRA. At the time there were a couple of European suggestions for similar apparatus. The British government turned one down flat. The Italian government let another die of inanition in a cubbyhole somewhere. The West German government said go, and G.A. Voss and colleagues went. Meanwhile, on the other side of the world good old U.S. efficiency was operating.

The American government does not decide. It dithers. And while the government dithered, the bureaucracy burned. The relevant bureaucracy was being reorganized from the Atomic Energy Commission to the Energy Research and Development Agency to the Department of Energy. At times like that the major preoccupation is preserving one's province on the table of organization and equipment, not operational activity.

PEP got its ground broken in May of 1977, and construction started in earnest that summer, according to Donald Getz, assistant director of SLAC. Came winter, and the curious case of a contractor who must have been listening to too many popular songs. That contractor was constructing the tunnel for PEP's 2.2-kilometer main ring. California's three-year drought broke, and the rains came. But, says Getz, "[the contractor] said, 'It doesn't rain in California. I don't know how to cope with it.'" It is *southern* California where the song says it never rains. The San Francisco area gets well drenched in normal winters. That happened in the winter of 1978, and work on PEP just stopped for months. In the complex interrelationships of construction operations the time was never made up, and one date after another slipped.

This combination of circumstances gave U.S. physicists quite a bit to gripe about. Many of them had concluded that colliding-beam experiments were the mode of the future, and they did not like seeing that future develop in another country. Propagandizing for a 100-GeV colliding-beam apparatus, Burton Richter, who directs SLAC's lesser-energy colliding-beam ring, called SPEAR, likes to stress the experimental and psychological advantages of coming in first with a machine like this. In the specific case of PETRA they seem to have been less than they might have been, possibly because of the nature of physics in this energy range — things are not as clear-cut as they used to be — possibly because of the nature of the experiments that go with colliding beams.

In the past, when someone completed a conventional fixed-target accelerator that opened a new energy range, physicists rushed to set up experiments specifically designed to find one or another phenomenon that they believed was available in that energy range. Bing, bang, bing, they either found them or didn't, often before a competing accelerator could get operational.

Colliding-beam experiments have specific goals, things they expect to find in this energy range, but their technique is most often to watch as much as they can in the hope of seeing what they want plus anything else that comes along. Almost anything in physics may come out of the annihilation reaction that occurs in the collision. The experiments try to sort this out and build up evidence for whatever they may be looking for and not miss anything unexpected at the same time. This can last a while, and it often involves more strenuous controversy than most past discoveries.

Characteristically it takes arrays of detectors wrapped around the point where the electron and positron meet. The layers tend to cover as much as practical of a full spherical volume around the intersection point, in some cases as much as the geometry will allow. (There have to be entry and exit pipes for the electron and positron beams.) Strolling through the tunnel that houses the ring-shaped vacuum tube in which electrons and positrons circulate, one comes to an experimental area as a literal jumping-off point. The floor suddenly drops by about a story in height, the ceiling rises by as much or more, and the walls spread out.

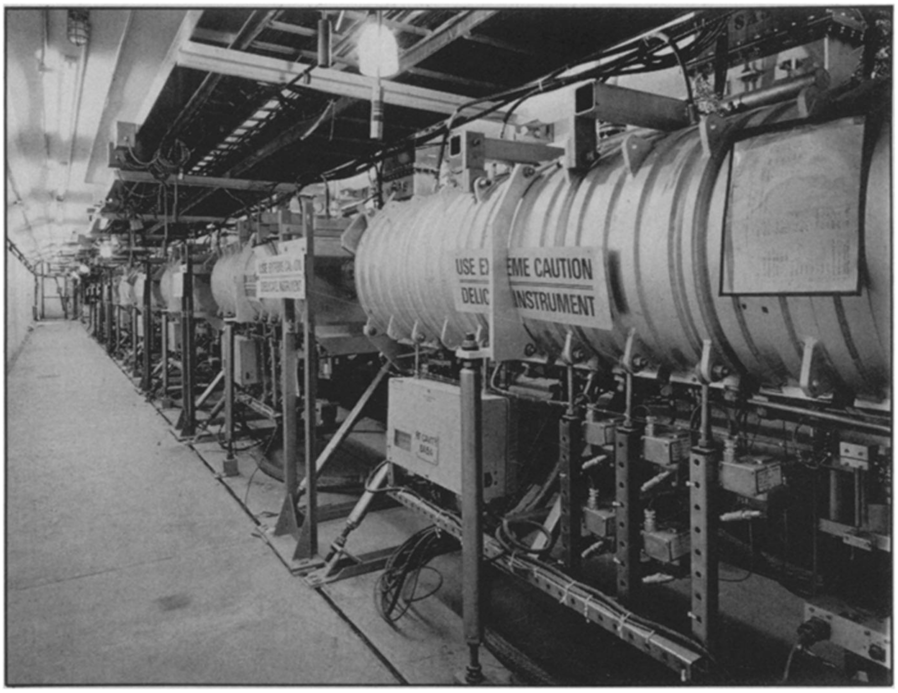
This is a burrow, in which physicists hope quantum chromodynamics and other goodies of the new physics will nest. When it is set up, one carefully woven detector with its electronics will fill most of this space. The electronics and computers that control, record and analyze data are a minor industry in themselves. PEP has six experimental areas.

John Rees, adjunct professor at SLAC, stresses that the various large detectors that will be used for the first series of experiments will look at events from varying points of view. Mark II is a "powerful general purpose detector." DELCO is good at following the drift of the particles. At its heart is a large Cerenkov counter to help it see where the particles go. It did the same thing for a long time at one of SPEAR's intersection points. (These detectors are so big, expensive and versatile and take so much of the working time of so many physicists — dozens to hundreds — that once they are built, they run for years and are moved from colliding beam to colliding beam.)

MAC is a magnetic calorimeter. It can measure the total energy deposited in itself of all the particles that carry energy away from the annihilation reaction. It can identify muons, which are an important end product in a number of processes that physicists wish to study at the moment. The Time Projection Chamber (TPC) will be able to follow the tracks of particles and collect samples of how they ionize matter at various points on those tracks. It could identify free quarks if such things exist. In the same area as TPC is the "two-gamma search," a detector that will observe particles generated when the annihilation produces two virtual photons rather than one. This is expected to be a very interesting new chapter of physics. Two small single-purpose experiments will be tucked away in parts of experimental areas: a search for magnetic monopoles, the hypothesized particles that are always sought, never found, and an independent search for quarks in linked bunches of three.

To service these experiments with electrons and positrons, PEP has the most energetic injector in the world, as Getz puts it. It is the accelerator with which the SLAC laboratory started, the four-kilometer-long linear accelerator that produces the world's most energetic electrons and positrons. They can be fed directly into PEP or SPEAR at the energy desired. This means that SPEAR and PEP operate independently of one another. The original plan at Hamburg had been to use DORIS, DESY's counterpart to SPEAR, to feed PETRA. Then it became clear that much useful physics remained to be done in the energy range of DORIS and SPEAR. SPEAR was still available, but DESY had to reverse field and build PIA, an accumulator ring for PETRA, to free DORIS.

Since PEP can take its electrons and positrons direct from the linear accelerator at the desired energy, it has the advantage that it needs to do only tune-up or touch-up accelerating in the ring. PETRA must do some accelerating, and a problem developed in trying to hold the magnetic fields that keep the particles on their circular orbits properly phased with the radiofrequency fields that do the accelerating. They had separate computer systems for the two functions, says Getz, "and the human hand can't twiddle the knob fast enough." PEP expects to avoid this by not having to accelerate and by having a central computer to tie everything together.



*Accelerating units restore energy lost by the particles through synchrotron radiation.*

The experiments that are going in at the beginning were selected by a PEP Advisory Committee. PEP was planned and constructed as a collaboration of SLAC and the Lawrence Berkeley Laboratory, a part of the University of California located at Berkeley. (SLAC is associated with Stanford University.) The construction budget was about $78 million, and the project has been completed just under budget. Once experimentation starts, PEP will lose its separate administration and be managed as part of the SLAC laboratory, although it will have an assistant director from LBL to represent LBL's interests. Programing for PEP will come under the general SLAC Program Committee. That will not change the customary formula that PEP is a national facility open to all qualified U.S. physicists — in practice to all qualified groups; the day of individual experiments in this business is past — and to foreigners by invitation. It merely shifts the burden for a lot of tough decisions. ☐