Racing After the Z Particle

Stanford's electron-positron collider has been plagued with hardware problems that have foiled efforts to begin exploring the physics of the Z particle

SINCE THE EARLY 1980s, particle physicists at the Stanford Linear Accelerator Center (SLAC) have been in a race with their European counterparts to be the first to explore the physics of Z particles, the existence of which was confirmed in 1983. And for a time it appeared as though American physicists had a lead over researchers at the European Laboratory for Particle Physics (CERN). This advantage, however, has been steadily narrowed by unforeseen operating problems with the experimental Stanford Linear Collider (SLC).

Now U.S. physicists are concerned that CERN will overtake SLAC in the quest to unlock the secrets of the electrically neutral Z particle. Often described as a particle factory, the Z leaves behind a trail of other particles as it decays. To date there have been few Zs to study.

The SLC and CERN's large electron-positron storage ring (LEP) will produce a flood of Zs and this is expected to provide researchers with multiple opportunities to challenge the validity of the so-called Standard Model. This model describes the interactions of fundamental particles and their relation to matter.

Just which of side of the Atlantic will make the most near-term headway in exploring such questions may be decided by who can produce the most Z particles most quickly. At one point the SLC had at least a 2-year lead on LEP. SLAC Director Burton Richter thought it possible that the SLC could produce 10,000 Zs by the end of 1988. Now it is doubtful that any significant number will be generated this year. Says Richter, "if we produce any Zs in the next few months, it will be by accident."

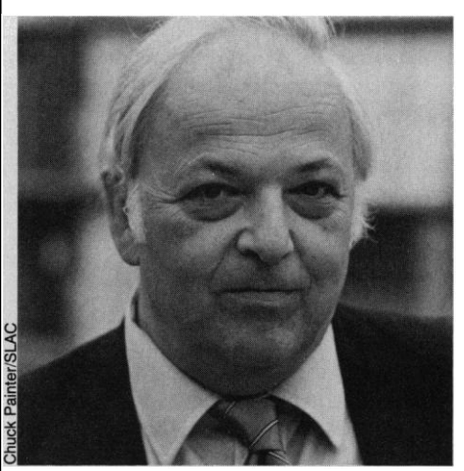
A key factor in the delays encountered by SLC is that this collider runs on old hardware that is being stressed beyond its design limits. The heart of the beast is SLAC's 2-mile long linear accelerator, or linac. It has been transformed into a collider by adding at the end two arcs that form a closed loop. Electrons and positrons shoot down the linac, are split into converging arcs, and collide within a central particle detector.

The SLC and LEP machines will allow physicists to confirm the mass of the Z, which under the Standard Model should be about be about 92 billion electron volts (GeV). It also will be possible to measure with precision the width of the Z, which under the Standard Model is predicted to be 2.7 GeV. Such exercises could help researchers confirm the existence of theorized particles such as Higgs boson and the top quark—or could add to doubts about Standard Model, which in some quarters is regarded as too complex.

The unique collider concept, which Richter dreamed up in 1978 as a way to open up Z physics, has presented a host of technical challenges. Overcoming these obstacles, plus adapting the laboratory's aging linac hardware, has proved to be more troublesome than was anticipated.

Complicating the task was the decision to have the two arcs follow the laboratory's bumpy terrain, instead of building them on a level plane. At the time this cost-saving measure was not seen as a potential source of trouble, but it has added to the problem of maintaining a proper beam profile and steering bunches of electrons and positrons through the arcs.

Earle C. Fowler, chief of facilities operations at the Department of Energy (DOE), is not unduly alarmed. He notes that Congress funded this $150-million project partly because it was a cheap way to demonstrate a new collider concept based on linacs and to study the physics of Zs. In contrast, LEP has cost more than $1 billion to build.



Burton Richter. *SLAC's director is focusing all the laboratory's resources on the SLC.*

Despite its problems, Richter contends that the basic concept has been proved, and he notes that the Japanese and Soviets are both pursuing colliding linacs.

The SLC, in fact, has cleared many technical hurdles. It was designed to produce electron-positron collisions with a center of mass of 100 GeV, but the new klystrons that slingshot particles down the linac will produce collision energies of 130 GeV. And physicists have managed to compress electron beams to an astonishing 4 micrometers, a level which should allow the machine to start producing an abundance of Z particles. On completion of the SLD, which is a second detector for the SLC, beams will be compressed further to 1.6 micrometers, thereby increasing the number of electron-positron collisions and the output of Z particles.

The fact the SLC is proving difficult to operate "is not surprising," says Georgio Brianti, technical director of CERN. "It is a novel machine, but I think they will get over their difficulties." The question being asked by frustrated researchers at SLAC and seven participating universities is "How much longer will it take?"

After encountering numerous problems keeping the collider operating in June for physics studies, Richter told *Science* that it became clear that "we were going to have to throw a lot more resources and people" at the SLC.

Personnel and program budgets across SLAC are being diverted to fix the machine. Work on advanced collider concepts and the completion of the SLD are being slowed. Richter also is borrowing top people from outside the laboratory to help with the collider.

What is keeping the SLC from operating properly? Gremlins, it seems. Refinements still must be made to beam alignments, particle bunch compression, and the final focus of the beams at the detector. But a principal challenge is getting various components of the 22-year-old linac to operate consistently day-in and day-out. These conditions have been impossible to maintain because:

- An inadequate water cooling system, along with record outdoor temperatures, have degraded the performance of electronic components and contributed to their failure.
- Failures in some of the 1200 power supply units governing the operation of this accelerator. Even when they are working, power levels cannot be controlled as precisely as SLC's engineers say is necessary.
- Some of the 240 modulators that con-

trol the pulse rate of klystrons, which accelerate bunches of electrons and positrons along the linac, are also giving out. Many of these truck-size devices are having to be replaced.

■ Kicker magnets that inject bunches of electrons and positrons from dampening rings into the front end of the linac for acceleration are not working properly. The shape of the pulse is not adequate. It does not rise quickly enough and its duration is too short.

These last three factors have contributed to an emittance problem where bundles of electrons and protons expand in length and width as they race down the linac and around the arcs to collision. Along the way some of the particles are striking the beam tube walls, releasing showers of muons that create unwanted background noise in the Mark II detector. This detector records the interaction of electrons and positrons and the release of Zs and other particles.

In addition to replacing components on the linac portion of the SLC, beam focusing magnets are having to be installed in the collider's arcs. Focusing magnets already exist at the final approach to the particle detector.

Unlike SLC, Europe's LEP is a classic synchrotron storage ring built with new hardware and it is unlikely to encounter the kind of delays that have afflicted researchers at Stanford. Indeed, John J. Thresher, director of research for LEP, told particle physicists gathered in Munich, in early August that this new electron-positron collider would produce 100,000 Zs by the end of 1989 and 10 million Zs by the close of 1990.

Just how quickly physicists at CERN can make productive use of the machine, Richter notes, will be depend on the quality of their software and diagnostic capabilities. SLAC may have an edge over LEP in this area, he says, because the Mark II detector is well understood. LEP will phase in four separate detectors.

At this point, Richter expects that the SLC will embark on a dedicated physics run in February and that the collider will yield at least a few hundred Zs by October 1989. In 1990 he expects the machine to produce 100,000 events. Whether this is adequate to compete with LEP is questionable. Comments Jay Chapman of the University of Michigan, "If by this time next year we only have 100 Zs, the physics will belong to LEP."

Richter rejects the notion that the SLC will lose out on near-term discoveries that lie waiting. "I don't believe it is so," he says, arguing that SLC will compete in the Z arena in the next few years and beyond.

■ MARK CRAWFORD

Academy Starts News Service

The National Academy of Sciences is going into the news business. But it's the news business with a twist: the Academy is reporting on itself.

On 1 October the Academy—together with the National Academy of Engineering and the Institute of Medicine—launches an ambitious and expensive news operation that it hopes will increase publicity for the three organizations and improve science coverage in daily newspapers. The National Academies News Service will be distributed by the *New York Times* syndicate. The service will provide articles about Academy reports and projects along with standard press releases. It will also include some feature articles about science, technology, and health issues aimed at a lay audience, drawing on Academy experts.

The news service expands on the Academy's own 5-year-old syndication service, which free of charge sent opinion pieces signed by prominent scientists to the op-ed sections of about 300 newspapers. Two-hundred-thirty newspapers published a piece at some time, according to David Jarmul, director of the op-ed service and of the new service.

The *Times* syndicate approached the Academy about taking over distribution of the op-ed service, and then convinced the Academy that the addition of news and feature stories would increase sales for the service by two to three times.

The syndicate sells the *New York Times* news service—a compilation of all stories from the *Times*, including those in the weekly *Science Times* section. It also sells a large number of features, including columns, puzzles, and magazine excerpts. Clients pay anywhere from $10,000 to $100,000 for various combinations of features, according to syndicate president Karl Horwitz. Editors will have to request the Academy's service and negotiate a fee for it. The *Times* syndicate declined to discuss possible fees for the Academy's service.

One question is whether editors will pay for a new science news service, since the *Times* provides extensive science coverage. Horwitz does not think the two services will duplicate coverage. "The Academy's got access to many of the world's best scientific minds. The *Times* has some of the world's best science writers. There's a difference," Horwitz said.

The service is promising at least one op-ed piece and one news story with an illustration each week, plus spot news coverage of major events, Jarmul said. Also possible are condensed versions of articles that appear in the Academy's quarterly *Issues in Science & Technology*. The pieces will be written and edited by Jarmul plus one science writer. Some, but not all, of the stories will be based on Academy doings. "Our mandate is to do what's newsworthy, not necessarily just Academy news," Jarmul said.

Jarmul says the Academy is concerned that "there were lots of subjects that weren't being covered in the general press." He cites a recent Academy report on chemical engineering as an example of an important topic that got little attention in the popular press. Jarmul's boss, Gail Porter, mentions a recent report on geothermal energy.

A second question is where the Academy will draw the line between public relations and news gathering. The news service is under the Office of News and Public Information, which oversees the Academy's public relations efforts. As a May 1988 Academy internal memorandum modestly states "It is especially unusual for an institution to provide information about its own activities through such a commercial syndication house."

Public information director Gail Porter says that Jarmul will have independence and has no public information duties. But Porter will also review the news service stories before they go out. "I would expect that controversial issues would be covered by news releases that clearly state they are institutional news releases," Porter said. "We would not try to cover ourselves in a news story on a controversial topic."

Although the Academy will not discuss the cost of the project or the details of the financial arrangements with the syndicate, the internal memorandum says the Academy will pay staff and production costs, expected to top $236,000 a year. The memo also says the Academy will not receive any royalty income. The project will run for 1 year; if the number of subscribers and of press clippings mentioning the Academy increase, the Academy plans to continue the service, but will look to private foundations for funding.

■ GREGORY BYRNE