Catching Some Zs

A particle physics experiment with a supercollossal cast

By DIETRICK E. THOMSEN

Cecil B. DeMille was famous for epic films based (sometimes loosely) on biblical themes, which always had "a cast of thousands." Particle physics may not yet have gotten that far, but it's reaching for it. The L3 experiment, being constructed to work with the Large Electron-Positron (LEP) collider at the European international laboratory CERN in Geneva, will involve 381 Ph.D. physicists and 745 engineers and technicians. Samuel C. C. Ting of Massachusetts Institute of Technology, who described L3 in Santa Fe, N.M., at the recent meeting of the Division of Particles and Fields of the American Physical Society, did not quote numbers for the workers involved in obtaining the raw materials and building the equipment. If he had, it might have been possible to refer to a cast of thousands here also.

L3 is also the first example of cooperation among the United States, the Soviet Union and the People's Republic of China in such an experiment. Other partners are Switzerland, France, Italy, West Germany, Spain and Sweden. One purpose of this and similar experiments is to study the details of the behavior of the newly discovered Z and W particles, which play an important intermediate role in subatomic processes.

Both LEP and its American counterpart, the Stanford Linear Collider (SLC), now under construction at the Stanford Linear Accelerator Center (SLAC) in Menlo Park, Calif., have been called "Z factories." Burton Richter, director of SLAC, told the Santa Fe meeting that the SLC should produce about 800 Zs an hour when it is working to the fullness of its design specifications. LEP should produce a similar number. The apparatus that discovered Zs and Ws, the CERN Super Proton-Antiproton Synchrotron, produces a number more like a few a month.

Ting points out that L3, for an experiment at a foreign laboratory, has a "heavy American involvement." The United States is contributing 45 million Swiss francs ($18 million) toward the cost of L3. The Soviet financial contribution will be 20 million Swiss francs ($8 million). The other partners will provide another 60 million Swiss francs ($24 million).

A major piece of equipment in L3 will be a large hadron calorimeter surrounding one of the points where electrons and positrons will collide in LEP. Hadrons are particles made of quarks, including protons, neutrons and related particles, a cast of more than a hundred. A calorimeter measures their energy as they come out of the annihilation of electron and positron.

Calorimeters are often made of a series of dense, heavy metal plates. The energy of the particles is determined by how many plates they penetrate. Iron, readily available and easy to work, has been a favorite material. L3's hadron calorimeter will be made of the heaviest of earth's naturally occurring metals, uranium. The Soviet Union will supply 400 tons of uranium 235, which will be fabricated into plates in a factory somewhere in the USSR. The Soviet Union is also providing 70,000 tons of low-carbon steel for a magnet that will be used to force electrically charged particles into curved paths, by which they can be identified.

Another piece of the apparatus will be a calorimeter for muons. (Muons, electrons and neutrons are not hadrons.) This will record muons with energies up to 45 billion electron-volts in a magnetic field of 5 kilogauss, 3.7 meters across. Its construction will require accuracy to 30 micrometers. It will consist of a honeycomb pattern of wires, some of which will provide forces to affect the motion of the muons while others sense the muons' passage. The frame for this apparatus will be made in a factory in Spain that usually makes airbuses. The frame will be shipped to MIT, where the wires will be installed.

The final calorimeter will record electrons. Thus the experiment will have calorimeters for nearly every kind of particle. The electron calorimeter will use a material in which the particles manifest their presence by producing scintillations of light. In the past the material of choice for such scintillation counters was sodium iodide. L3's electron calorimeter will use a newly developed material, bismuth germanate (BGO).

The raw material for the BGO, 3.5 tons of germanium oxide, will come from the Soviet Union. To make the BGO, the Chinese are setting up a special factory in Shanghai involving 200 physicists under the direction of Yin Zhi Wei. For some reason—Ting doesn't know exactly—the raw material cannot be shipped directly from the Soviet Union to China, so it will go through Switzerland.

The final piece of equipment is a time expansion chamber. In such a chamber, particles, moving through a gas, leave behind trails of ionized atoms. The ionization products are attracted to sensor wires, and from the geometry of the wires and the time it takes the ionization products to reach them, the apparatus can deduce the path and the nature of a given particle. A half-scale model of this has been built and is being tested at Aachen, West Germany.

The entire experiment will be mounted in the LEP tunnel 50 meters underground. There are limitations to the size of components that can be lowered through the access shaft, so most of L3 will be assembled in the tunnel. The experiment was authorized by the CERN management in June 1982. Ting expects its construction to take three more years, that is, to about the beginning of 1988. CERN also expects to complete LEP sometime in 1988.

And, in case anyone was wondering, no, the great pyramid that DeMille's toiling Egyptian serfs so laboriously constructed has nothing like this in its center. □