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Fusion experiments have begun at Antares

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tance, the product of its angular and spatial spread in a given direction normal to the beam axis. To provide reasonable confidence that SLC can yield a luminosity of at least 10^{29} $sec^{-1}cm^{-2}$, it was felt that at this stage one must demonstrate the acceleration of bunches containing 10^{10} electrons to 6.5 GeV with horizontal and vertical emittances of no more than about 3×10^{-9} mrad. This was accomplished, with some fanfare, shortly before dawn on 4 February.

The ultimate goal is to run with electron and positron bunches each containing 5×10^{10} particles. A high-current electron gun capable of producing such large bunches was already in place at the time of the February test, but the extra-strong focusing needed to transport them to the first accelerating stage of the linac was not installed until July.

How will the positron bunches be produced? The SLAC linac traditionally accelerates only electrons. SLC will operate at a repetition rate of 180 cycles per second. In each of these cycles, the linac will accept two new electron bunches from the injector. After a respite in the electron damping ring, both bunches are accelerated down the linac, but one is diverted near the far end to strike a "positron-production" target. Among the debris produced in this high-energy collision with the tungsten–rhenium target is a profusion of low-energy positrons, which are collected, accelerated to 200 MeV, and then transported back to the injection end of the linac through a separate return line now under construction in the main linac tunnel.

After a further acceleration in the first stages of the linac, the positron bunch spends *two* machine cycles in the positron damping ring—twice as long as the electron bunches because its initial phase-space spread is so much greater. After damping, the positron bunch continues down the linac, joined by one of the two electron bunches from the subsequent machine cycle. Separated by 17 meters, the two oppositely charged bunches are accelerated to 50 GeV by opposite phases of the 3-GHz rf wave propelling them down the linac. Emerging from the 2-mile linac, the e^+ and e^- bunches go their separate ways in the collider arcs, finally colliding after being focused down to micron size.

The luminosity of a collider is of course proportional to its effective repetition rate. Having to accelerate fresh bunches every cycle limits SLC to a rather slow rate of 180 Hz. This must be compared with the hundred times faster rate at which countercirculating bunches stored in the LEP ring complete their 27-km course, passing through one another again and again. The linear collider compensates by having much denser bunches.

In this regard the fact that linear-collider bunches are discarded after one pass is something of an advantage. When very dense charged-particle bunches pass through one another, their reciprocal electromagnetic interaction is a serious source of "beam–beam" perturbation. In a single pass, this perturbation does little harm; but with the repeated passes of a storage ring it puts an upper limit on the tolerable charged-particle density in a bunch. LEP could not increase its luminosity by compressing its bunches to anything like micron dimensions.

The design luminosity of LEP is 1 to 2×10^{31} sec^{-1} cm^{-2}, two or three times that of SLC. But, Richter points out, this is the *peak* luminosity. In a storage ring, the beam intensity, and hence the luminosity, begins a steady decay from the moment the ring is filled. From experience with similar, albeit much smaller, e^+e^- rings, Richter argues, one must divide the peak LEP luminosity by a factor of two or three to compensate for filling time and beam decay in arriving at the effective time-averaged luminosity. Thus, he concludes, the time-averaged design luminosities of LEP and SLC are about the same.

With four experimental collision points, compared to only one for SLC, LEP can of course observe four times as many interesting events per unit time even if both machines have the same luminosity. Furthermore, "you'd have to be an even crazier optimist than I'm

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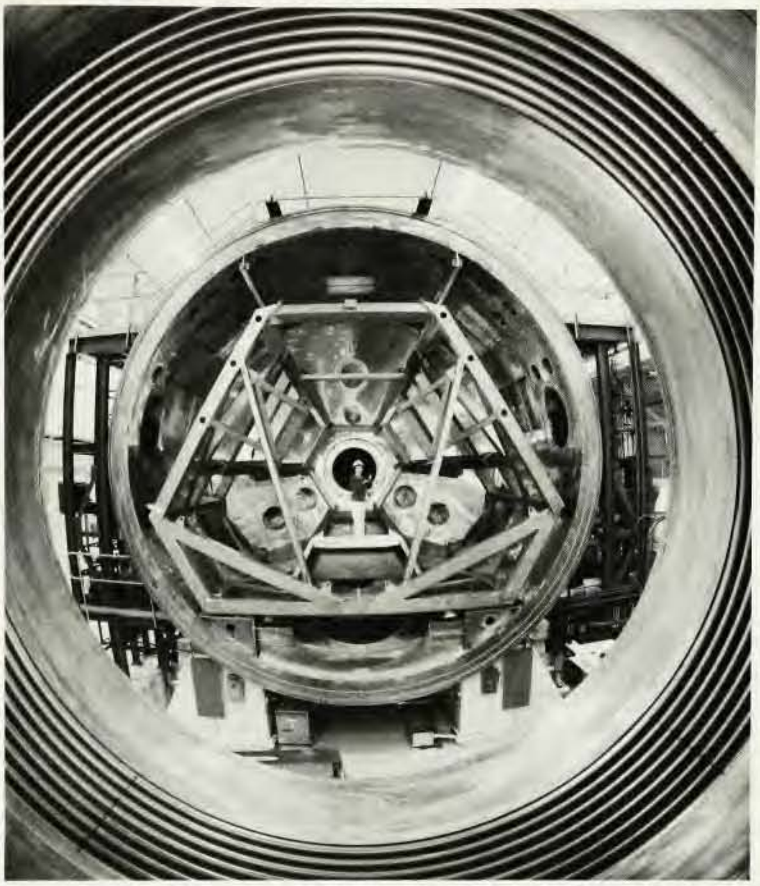

Antares, the world's highest-power CO_2 laser, was ceremonially dedicated at Los Alamos in January. Experiments had in fact begun a month earlier. The purpose of Antares is to evaluate the feasibility of CO_2 lasers as drivers for inertial-confinement fusion. The system's 24 laser beams are focused onto a 100-micron-diameter deuterium–tritium target pellet, delivering 25-kilojoules of 10.6-micron, infrared light in nanosecond pulses. It is anticipated that Antares will eventually run at 40 kJ.

The picture shows the space frame inside the Antares target chamber. Although the shorter wavelengths put out by neodymium glass lasers such as Nova (page 20) are expected to couple more efficiently to D–T fusion pellets, CO_2 gas lasers are of particular interest for practical laser fusion because they can sustain much higher repetition rates, tolerating heat levels that a solid-state lasing medium probably could not survive.