charged tracks or photons. Although some such events were indeed found, they could all be explained as misidentified hadronic events. By December, 1975, Feldman and Perl thought[1] they had found heavy leptons. However, other groups at SPEAR and at DORIS, the storage ring at DESY in Hamburg, were not seeing them.

The following year a new signature for heavy-lepton production was observed. This was an event with two charged particles, one of which was identified as a muon. A Princeton–Maryland–Pavia group reported 12 such events. Then the SLAC–LBL group observed 100 μ–X events in which X could be a hadron or electron but not a muon. By then, Perl recalls, his group was fairly convinced they were not seeing charmed mesons.

In the summer of 1976 Hinrich Meyer (University of Wuppertal) reported at the SLAC summer institute that the Pluto group was seeing electron–muon events. Although the DASP group at DESY saw some indication of the heavy lepton, their statistics were not significant. At this point many physicists questioned the heavy-lepton explanation for the e–μ events.

Then Perl and his collaborators joined forces with Lena Barbaro-Galtieri (LBL) and her group, calling the team the lead-glass wall group. In this experiment, they covered $\frac{1}{8}$ of the magnetic detector with lead glass to improve the detection of electrons.

By the beginning of 1977 the DASP and Pluto[2] groups began to see e–μ, e–X and μ–X events. Meanwhile, still another group was tooling up at SLAC, installing the Delco detector in the East Pit of SPEAR. (The SLAC–LBL magnetic detector was installed in the West Pit.) The Delco group was a collaboration among Stanford, University of California at Irvine and UCLA. Delco has ten times the solid angle of the lead-glass wall detector and can reject pions down to very low momentum, making it more difficult for a pion to fake an electron. The Delco group was able to analyze their data in time for the Hamburg meeting. At that time Jasper Kirkby (Stanford) said his group, too, finds no contradiction with the heavy lepton. The most interesting evidence was an apparent smooth (pointlike) production of e–X events as the beam energy was increased, in contrast with the violent oscillations they observed in multi-pronged events (which are due to charmed particles).

"How can you be sure you're seeing a heavy lepton and not a meson?" we asked. Kirkby wryly remarked, "There's no smoking gun." Perl described five pieces of evidence for a heavy lepton:

▶ If one has a charmed meson, one would expect the number of e–μ events to go up by factors of two or three at 4.1 and 4.4 GeV because the D mesons would be produced at those energies. Such an increase in production cross section is not seen.

▶ At higher energies, in the range 6–7.8 GeV, charmed mesons would be produced with lots of hadrons. Instead, the purity of the signal stays the same, even at high energy.

▶ When the D meson decays into an electron plus hadrons or a muon plus hadrons, the electron or muon generally has a momentum less than 100 MeV/c, whereas in typical electron–muon events the electrons and muons have momenta greater than 100 MeV/c.

▶ If the new particle were an ordinary baryon, the production cross section would be lower. Furthermore, once the energy was high enough to produce them, as the energy were increased further, additional hadrons would be observed. They were not observed.

▶ If the τ is a heavy lepton, it should follow the predictions of quantum electrodynamics, which says that the production cross section should vary as the inverse square of the total energy. The observed[3] cross section agrees with theory within 20–30%.

What next? All the experiments have had difficulty pinning down the exact mass of the τ. Because it decays with at least one undetectable neutrino, it is tough to tell exactly what the mass is. The ψ''(3772) resonance is just a trifle more massive than half the mass of the D_0 (1863 MeV) or D_0^+ (1868 MeV); so the ψ'', recently reported by the SLAC–LBL group, decays to D mesons. While running in that energy region, one can look for the τ. If it is not seen, the τ mass is greater than 1868 MeV. If it *is* seen, the τ mass is less than 1868. Both the lead-glass wall and Delco groups have seen some indications of τ being formed.

The very convenience of the D meson's mass being so close to that of the τ is also a profound disturbance to the experimenters. Perhaps the τ is in reality the D. Yet for all the reasons he outlined, Perl is sure that it is not. Is the similarity in mass just a coincidence or does it mean something? Only two groups have published values for the mass. The SLAC–LBL group gives (1.9 ± 0.1) GeV. Gerhard Knies (DESY) of the Pluto group said at the Hamburg meeting that the τ mass is (1.93 ± 0.05) GeV.

Another problem is that not all the expected decays of the τ are observed. So far the experimenters at DESY and SLAC have seen τ going to e + 2 neutrinos, μ + 2 neutrinos, ρ + 2 neutrinos and the A_1 meson plus a neutrino. But if τ is a conventional lepton, one would expect to see $\tau^- \to \pi^- + \nu$. At the Hamburg meeting, S. Yamada of the DASP group reported that this decay is not observed with a 3–4-standard deviation error.

Assuming that the τ *is* a heavy lepton, very likely it has its own neutrino associated with it. Perl explained that the τ cannot have the same lepton number as the muon or the τ would have been observed as neutrino-induced events at bubble chambers, and it was not. However, the τ could have the same lepton number as the electron. Both the SLAC–LBL and Pluto groups have established upper limits on the mass of the tau neutrino, in the same fashion as the mass of the ordinary neutrino is obtained from a beta-decay spectrum. From the e–μ mode, SLAC–LBL finds that the mass is less than 600 MeV/c^2. And from e–X events, Pluto sets an upper limit of 540 MeV/c^2. From their two-body decay events into A_1 and neutrino, Pluto infers an upper limit of 300 MeV/c^2. If there is a τ neutrino, we would have six leptons. And one can argue, we should by symmetry have six quarks. Or more. —GBL

References

1. M. L. Perl et al., Phys Lett. **63B**, 117 (1976).
2. H. Meyer in Proc. of the Orbis Scientiae-1977, Coral Gables, 1977.
3. M. L. Perl et al., Phys. Lett., to be published.

Solar test facility yields 1.7-MW power

ERDA's Solar Thermal Test Facility, at Sandia Laboratories near Albuquerque, recently produced 1.7 MW, making it the largest operational solar installation in the world, although it is still being constructed. It exceeded the 1-MW capacity of the solar facility at Odeillo, France.

The facility is expected to reach its full capacity of 5 MW in December. It cost about $21 million. When operational, the test facility will be used to resolve technical questions concerning the design and development of commercial solar electric power plants, to test prototype solar boilers and other components under development for the planned 10-MW electric power plant near Barstow, California, to develop high concentration ratio photovoltaics, and for advanced high-temperature materials studies.

in brief

Michigan State University recently received $400 000 from NSF, the first installment of an award of $1.2 million, to build the first of a pair of superconducting cyclotrons. NSF is considering a $12-million proposal to build a second cyclotron. The facility would be used to accelerate heavy ions.

A $1-million laser center will be established on the Chicago campus of IIT Research Institute and will be dedicated to the extension of laser technology into manufacturing and production. The facility will have an Avco 15-kW cw industrial laser. □