This Week's Citation Classic®

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Phys. Rev. Lett. 35:1489-92, 1975. [Lawrence Berkeley Lab. and Dept. Phys., Univ. California, Berkeley, and Stanford Linear Accelerator Ctr., Stanford Univ., CA]

The discovery of electron-positron annihilations in which only a muon and an electron are detected is described. There was no conventional explanation at that time for such events in elementary particle physics. This led to our discovery of a new particle, the tau lepton. [The *SCI*® indicates that this paper has been cited in over 440 publications since 1975.]

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Since the 1930s physicists have been puzzled by the existence of two similar elementary particles, the electron and the muon. Most of their properties are the same, indeed they are so similar that they have a family name—lepton. But the muon has 200 times the mass of the electron! Since no meaningful connection was found between the electron and the muon, they came to be called the first and second generation respectively of the lepton family, and the lack of a connection was called the generation puzzle.

After spending about five years trying experimentally to solve the generation puzzle, and failing, I decided in about 1970 to go in a different experimental direction—to search for more lepton generations. This was made possible by the building, under the leadership of Burton Richter, of the Stanford Positron Electron Asynchronous Ring (SPEAR) collider at the Stanford Linear Accelerator Center.

As we began to collect data in 1973, I was not very hopeful because our search for additional leptons was over a quite limited mass range. To my great surprise, in 1974 we began to find events in which only a muon and an electron were detected but which events were unexplainable by the then-current theory of elementary particle physics. They could be explained by a new, massive lepton, however.

By 1975 we were sufficiently sure of our results to publish this paper, but we were not sure of the new lepton explanation, hence the emphasis on "no conventional explanation" in the abstract of the paper. I had to argue with some of my fellow authors for the last line of the paper: "A possible explanation for these events is the production and decay of a pair of new particles, each having a mass in the range of 1.6 to 2.0 GeV/c^2."

This explanation turned out to be correct. The new particles, now called tau leptons, have a mass of about 1.78 GeV/c^2, so even the rough guess at the mass was correct. This mass is about 3,500 times the mass of the electron, otherwise the tau's properties are similar to those of the electron and the muon. Paradoxically, we did not succeed in answering the generation puzzle, but only added to it, since the lepton family now has three, still unexplained, generations. (Subsequent to this work, a third generation of quarks was also found and is also unexplained.)

This paper has been often cited for three reasons. First, it introduced a new lepton and the realization that there was a third generation of particles. Second, the tau opened up a new area of particle physics[1] because it is massive and decays in many different ways. Third, this 1975 paper was greeted with skepticism by most particle physicists; full acceptance and confirmation did not occur until 1979.[2] Many papers were published arguing about the correctness of our data and our explanation. For me, it was a very nervous four years. This was more than compensated for by later receiving the Wolf Prize in Physics in recognition of our discovery of the tau.

1. Gilman F J & Rhie S H. Calculation of exclusive decay modes of the tau. *Phys. Rev. D—Part. Fields* 31:1066-73, 1985.
2. Perl M L. The tau lepton. *Annu. Rev. Nucl. Par. Sci.* 30:299-335, 1980.

