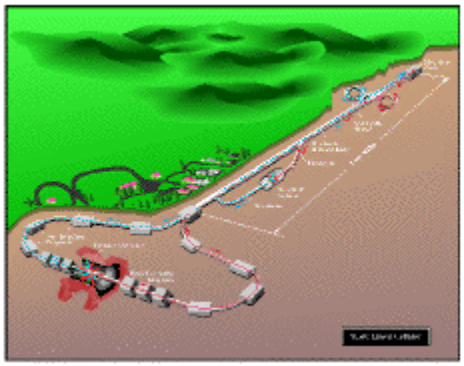
3.2 Discovery of One of the Smallest Particles of Matter



The vertex detector used in this experiment at the Stanford Linear Collider.

Forces of nature are mediated by the interaction or exchange of particles called bosons. In 1989, experiments at Stanford Linear Accelerator Center and the European Laboratory for Particle Physics (also known as CERN) made precise measurements of the lifetime of the Z0 boson, which carries the "weak force" that allows particles to change form. The experiment was significant because it implied that only three families of fundamental particles exist. That's because the Z0 boson is short-lived and decays to certain other particles; the number of these particles influences the decay process. Precise measurement of the Z0 boson lifetime revealed that only three particles called neutrinos are produced. (If additional neutrinos were involved, then the Z0 boson would have additional ways to decay and thus a shorter lifetime than was indicated by the experiment.) This conclusion, which was supported by other studies, implies that only three families of matter exist. All three families have now been observed.

Scientific Impact: This work placed a firm cap on the possible complexity of the universe, at the level of its fundamental constituents. The results agreed with the Standard Model, physicists' current understanding of matter and the forces of nature.

Social Impact: These studies answer questions about the constituents and history of the universe, extending human understanding of nature and contributing to improvements in science education. In addition, although basic research is by definition a search for new knowledge without regard to its practical implications, such work often contributes to technologies with commercial value; examples include computers, lasers, and cancer treatments.

Reference: "First Evidence That the Number of Light Neutrinos = 3," G. S. Abrams et al., *Phys. Rev. Lett.* 63: 2173 (1989).

SC-Funding Office: Office of High Energy and Nuclear Physics