Neutrino History and Mystery
Time Line

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1914 – James Chadwick observes continuous energy spectrum in β decay.

1927 and 1929 – Continuous β decay energy spectrum confirmed.

1930 – Wolfgang Pauli suggests a "neutron" in nucleus as part of beta-decay to account for continuous beta energy spectrum and nuclear spin statistics discrepancies.

1932 – James Chadwick demonstrates the existence of a neutron (with mass comparable to proton) in nuclei.

1934 – Enrico Fermi proposes a theory for β decay and renames Pauli's "neutron" a "neutrino."

1936 –Carl Anderson and Seth Neddermeyer discover muon.

1940 – E. J. Williams and G. E. Roberts are the first to observe $\mu^+ \rightarrow e^+ +$ neutral(s) in cloud chamber

1941-1942 – F. Rassetti, B. Rossi, N. Nereson measure muon mean lifetime with increasing accuracy with coincidence and anti coincidence particle counters: $\tau_\mu = 2.15 \pm 0.07\ \mu s$

1945 – Bruno Pontecorvo suggests looking for neutrino interaction $\nu_e + {}^{37}_{17}\mathrm{Cl} \rightarrow e^- + {}^{37}_{18}\mathrm{Ar}$ followed by ${}^{37}_{18}\mathrm{Ar} \rightarrow^{\mathrm{EC}} {}^{37}_{17}\mathrm{Cl} + e^- + \gamma \quad (t_{1/2} = 35\ d)$

1947 – Cecil Powell, *et al*. discover pion and observe decay to muon.

1956 – Fred Reines and Clyde Cowan detect electron anti-neutrinos from the Savannah River nuclear reactor: anti-$\nu_e + p^+ \rightarrow n + e^+$ followed immediately by $e^+ + e^- \rightarrow \gamma + \gamma$ then several μs later $n + {}^{108}_{48}\mathrm{Cd} \rightarrow {}^{109\mathrm{m}}_{48}\mathrm{Cd} \rightarrow {}^{109}_{48}\mathrm{Cd} + \gamma$.

1956 – T. D. Lee and C. N. Yang point out lack of evidence for parity conservation in weak interactions. C. S. Wu, *et al*. demonstrates parity non-conservation for β decay of Co-60 nuclei. R. Garwin, L. Lederman, and M. Weinrich demonstrate parity violation for $\pi^+ \rightarrow \mu^+ + \nu$ and $\mu^+ \rightarrow e^+ + 2\nu$

1958 – Bruno Pontecorvo suggests that a supernova would produce a burst of neutrinos.

1959 – Bruno Pontecorvo suggest possible distinction between ν_e and ν_μ .

1962 – Leon Lederman, Jack Steinberger, and Melvin Schwartz observe muon neutrinos

1960s – Bruno Pontecorvo develops the possibility of neutrino oscillations.

1964 – Ray Davis works on detecting solar ν_e neutrinos with tanks of C_2Cl_4 (perchloroethylene) in a limestone mine.

1970 – Ray Davis begins solar neutrino experiment in Homestake mine in Lead, SD. He finds about 1/3 as many electron neutrino interactions as predicted by John Bachall's theory of solar energy production.

1973 – Weak neutral currents observed with Gargamelle bubble chamber at CERN.

1975 – Tau lepton observed by Martin Perl, *et al*. from e^+e^- collisions at SLAC – first particle of third generation.

1987 – SN1987A supernova in the Large Magellanic Cloud produced neutrinos that are detected by IMB detector near Cleveland and by Kamioka Nucleon Decay Experiment detector in Japan

1998 – Super-Kamiokande detector (50,000 tonnes of ultrapure water) provides evidence for neutrino oscillations and a solution to the "solar neutrino problem."

2000 – DONUT experiment at Fermilab detects ν_τ in nuclear emulsions.

2001 – SNO (Sudbury Neutrino Observatory) detector (1000 tonnes of heavy water) provides evidence for neutrino oscillations from the reactions:
$\nu_e + n \rightarrow p^+ + e^-$ and (any ν) + $d \rightarrow p^+ + n$.
Analysis of these interactions confirms oscillation of solar neutrinos.