1931

J.Chadwick discovers the neutron.

1932:

Anderson discovers the positron, e^+, in cosmic rays.

W.Heisenberg introduces the (strong) "isospin":

- W.Heisenberg realizes that p and n with respect to the strong (nuclear) force can be considered to be two states of the same particle, the "nucleon". The small mass difference ($<$ 1 MeV) is of the typical size of electromagnetic effects which can be neglected compared to the strong force.
- In the same way as electrons with spin up and down are considered to be the same particle, the isospin is introduced to distinguish between the proton (I_3=+1/2) and the neutron (I_3=-1/2). These two components of the nucleon state form a spinor in the abstract three-dimensional isospin space.
- The (approximately) same mass is now understood to be due to the invariance of the strong force under rotations in this isospin space.

1932-33:

Stern, Estermann and Frisch measure the magnetic moment of the proton and find $g_p \sim 2.5 \Rightarrow$ The proton must have structure.

1933/34:

Fermi formulates a theory of the β decay by describing the β decay of the neutron, $n \to pe^- \bar{\nu}_e$, in form of a local four-fermion interaction (weak interaction). Using data from β decays he estimates the coupling constant (Fermi constant) to be $G = 0.3 \cdot 10^{-5}\ \text{GeV}^{-2}$, and deduces that the mass of the neutrino must be very small or zero.

1935:

Yukawa combines Quantum Mechanics and special relativity to describe nuclear interactions by an exchange of a new massive particle, the π-meson:

Compton wave-length of the quantum of the force field = 1/mass = range of the force field

From data from pn scattering and the binding energy of the deuteron, Yukawa estimates the Compton wavelength (size of nucleus $\to$ range of strong force) and the mass of the pion as follows:

$$1/m_\pi = 10^{-12} - 10^{-13}\ \text{cm and } m_\pi = 20 - 200\ \text{MeV}$$

Interpretation: Interactions are due to the exchange of field quanta. Equivalence of force and particle exchange.

1938:

Kemmer extends the notion of "isospin" to Yukawa's π-mesons. He postulates that they form a isospin triplett, that is a system with $I = 1$. This requires the existence of a neutral pion.

1947:

Powell discovers the charged π-meson in cosmic rays.

It is realized that the cosmic ray particle observed in 1936 by Anderson and Neddermeyer and thought to be Yukawa's pion is instead a "muon". It is the first second generation particle discovered and thus was completely unexpected.
Rabi: *Who ordered that ?*

Butler and Rochester observe longlived so-called V particles in cosmic rays, which was the first evidence for K-mesons and Λ-hyperons.

1948:

Feynman, Schwinger, and Tomonaga create the covariant theory of electrons and photons and their interactions: Quantum Electrodynamics (QED) – First example of a Quantum Field Theory with direct experimental applications (e.g., anomalous magnetic moment of the electron/muon, Lamb shift)