1967/68:

Weinberg and Salam formulate a unified (not quite: still two coupling constants, $g, g'$, for the SU(2) and U(1) interaction) theory of electromagnetic and weak interactions of leptons.

It is a local gauge theory based on the symmetry group $SU(2)_I \otimes U(1)_Y$ ($I$: weak isospin,$Y$: hypercharge, $Q = I_3 + Y/2$) where the lefthanded leptons are grouped in SU(2) doublets (and righthanded leptons in singlets).

Following Yukawa's suggestion, the weak force is understood to be transmitted by the exchange of massive gauge bosons, i.e. for instance the muon decay can be written as follows:

$$\mathcal{L}_{WS} = g_w^2 J^\mu_{lept} \frac{g_{\mu\nu} - q_\mu q_\nu / M_W^2}{q^2 - M_W^2 + i\epsilon} J^\nu_{lept}$$

The requirement $\mathcal{L}_{WS} \overset{q^2 \ll M_W^2}{\to} \mathcal{L}_{Fermi}$ yields a prediction for the mass of the charged weak gauge boson, $W^\pm$:

$$M_W^2 = \frac{\sqrt{2} g_w^2}{G_\mu} \sim (100 \text{ GeV})^2$$

where it is assumed that $g_w \sim e$.

The structure of the gauge couplings is governed by the requirement that the theory ($\equiv$ Lagrangian) is invariant under $SU(2)_I \otimes U(1)_Y$.

Based on works by Higgs, Kibble, Brout, Englert and Guralnik, Hagen, the masses of the weak gauge bosons are generated via the interaction with a massive neutral scalar field, the Higgs boson, so that the gauge invariance of the Lagrangian is preserved and only the vacuum state is no longer invariant (*spontaneous symmetry breaking*).

The WS model predicts the existence of a neutral weakly interacting boson ($Z^0$), that mediates a weak interaction (neutral currents) which has not been observed yet.

It also predicts the existence of the Higgs boson.

1968/69:

In experiments where electrons are scattered off nucleons (deep inelastic $eN$ scattering) the electrons appear to be bouncing off small hard cores inside the nucleon.

To analyze these data Bjorken and Feynman introduce the parton model, a model of constituent particles inside the nucleon (they did not yet call them quarks):

- Assumption I

  A fast moving hadron can be viewed as a jet of partons which predominantly fly in the direction of the hadron and the momentum of the hadron is distributed among the partons.

- Assumption II

  The cross sections for hard processes such as deep inelastic $eN$ scattering are calculated by calculating the cross sections of the underlying subprocesses assuming free point-like partons and then summing incoherently over the contributions of all partons.

The parton model succeeds in explaining the experimentally observed *Bjorken scaling*.