Chapter 1

Top-quark physics

The third generation of quarks was first proposed by Kobayashi and Maskawa in a paper published in 1973 [1] as a way to explain the CP violation observed in Kaon decays. The existence of the third generation was confirmed when the lighter of the two constituents, the b-quark, was discovered in 1977 [2].

Due to its large mass, direct confirmation of the existence of the top quark required the construction of very powerful accelerators. The top quark was discovered by the CDF and D0 experiments at Fermilab in 1995 [3, 4] and then observed at CERN in 2010 [5, 6].

The large mass of the top quark makes it a very interesting object of study. The current world average for the mass of the top quark, based on results from Tevatron and the LHC [7], is

$$m_t = 173.07 \pm 0.52\,(\text{stat.}) \pm 0.72\,(\text{syst.})\,\text{GeV}$$

Due to its mass the top quark has an extremely short lifetime $\tau \approx 0.5 \times 10^{-24}$ s, too short to interact via the strong force and hadronize into a bound state [8]. Instead the top quark decays weakly producing a W boson and a b-quark almost exclusively. This allows experimentalist to directly study the properties of a bare quark. An impossibility with the other quarks which bind with other quarks to form hadrons. Measurement of top quark properties (mass, charge, forward-backward asymmetry, couplings, etc…) forms a large part of high energy physics research. Measurement of these properties provide rigorous tests of the SM, point towards the existence of new physics or exclude some BSM theories.

From an experimental perspective, top quark decays can produce a very interesting signature which includes leptons, jets and transverse missing energy $E_{\mathrm{T}}^{\mathrm{miss}}$ due to the escaping neutrino[1]

Bibliography

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