Beyond the Standard Model physics

- Extensions of the scalar sector:
  The Standard Model (SM) of electroweak interactions contain a single fundamental scalar degree of freedom, the celebrated Higgs boson, that has been introduced to construct a theory that is renormalizable. Renormalizability is, simplifying a bit, a feature of a theory that allows, in efficient and elegant manner, to eliminate divergences that appear in the perturbative expansion, the best studied renormalizable theory is the quantum electrodynamics. In the SM, the Higgs sector (i.e. the scalar fields which are present in the Lagrangian) is minimal in the sense that it is just sufficient for the renormalizability. In view of the fact, that there exist many fermions (leptons, quarks) and vector bosons (photons, gluons, massive gauge bosons), the presence of just one elementary scalar seems to be odd. This is why many possible extensions of the SM predicts some sort of extension of the Higgs sector. The simplest possibility is to add gauge singlets to the theory. That is however rather trivial extension, with little phenomenological consequences. On the other hand, adding number of SU(2) doublets changes the theory of electroweak interctions substantially providing at the same time means to solve some of theoretical difficulties of the SM. One of them is the SM mechanism of breaking the CP symmetry (its breaking was observed in K and B meson decays, it is also needed to explain the lack of anti-matter in the observed Universe). The strength of CP braeking in the SM is not sufficient to explain the lack of anti-matter, while extended Higgs sector provides new sources of CP violation, therefore multi Higgs doublet models provide an atractive alternative to the SM Higgs sector. CP violation in the Higgs sector can be tested both at the Large Hadron Collider and at planed linear electron collider (ILC). Many observables sensitive to CP violation have been constructed (see e.g. [1]-[17]) so far, but a complete phenomenological analyzis focused on LHC is still missing.

- Experimental determination of top quark properties:
  The top quark is very, very heavy, its mass is about 174 GeV, while the next lighter quark, the b quark, has mass about 4.5 GeV. The huge top mass makes us to believe that its properties could be very different from those of lighter quarks. On the other hand, the extensions of the

scalar sector of the electroweak theory predicts substantial modification of top quark couplings and/or decay modes. Therefore experimental efforts focused on measurements of the top quark couplings to vector bosons or Higgs boson are very essential on our way to reveal the more fundamental (more then the SM) theory of electroweak interactions. Existing data from the Tevatron or B-meson decays can already now impose some constraints on the $tbW^{\pm}$ couplings, however very little is know concerning $tt\gamma$ or ttZ couplings, not mentioning ttH. Therefore it is very essential to construct observables which could be measured at LHC or ILC that are sensitive to the top couplings. Again a complete phenomenological analysis focused on LHC is still missing. Some discussion of observables sensitive to non-standard top quark interaction could be found e.g. in [18]-[29].

- Effective Lagrangians:
  A very efficient way to parametrize deviations from the SM is the method described Buchmuller and Wyler in [30]. Following their classification one can investigate in a systematic way properties (like e.g. stability and triviality) of the Higgs boson in extensions of the SM, see e.g. [31]-[33]. The effective Lagrangian is also a very useful toll while discussing (in a consistent and gauge invariant way) non-standard top-quark couplings, see e.g. [34].

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