Minutes of the LHC HXSWG BSM meeting, Friday 15. 5. 2013

In this meeting we continued to discuss 2HDM benchmarks. One of the main problems we are facing is that already a **large parameter space is excluded by constraints from unitarity and perturbativity**, as Nikos and Oscar showed in their talks. Assuming some Higgs mass degeneracy and fine tuning m12 was not helping much in this regard. In the discussion, it was also agreed on that the current observation of the experiments at 125 GeV should be fully taken into account. This will lead to scenarios with $\sin(\beta - \alpha)$ very close to 1.

Howard was presenting a strategy for choosing 2HDM benchmark points. For this approach, the model is written in the **Higgs basis**, where unitarity constraints are explicit. To choose benchmark points, the observation at 125 GeV is identified with h1. Parameters s12 and s13 are chosen such that h1VV couplings are SM-like. Now one can choose the remaining parameters such that they satisfy unitarity. Finally, we need to convert back to the mass-eigenstate basis used by SusHi and 2HDMC.

In the searches **Higgs width effects** should be controlled. As Oscar showed, they can be calculated with the 2HDMC. For some parameter choices the H width can be enhanced in the low mass range compared to SM case. The H width can also be very large when approaching the non-perturbative regime.

Oscar and Robert also work on an “official” **interface between SusHi and 2HDMC**. Here the cross section calculation can be set up in SusHi which is linked to 2HDMC for calculation of physical masses and mixings, theoretical constraints, and branching ratios. The public version of this is already in preparation, and will soon be available for interested LHCXSWG members for early testing.

Gunar discussed changes in the **Higgs pT wrt tan β**. At high values of tan β the bottom contributions become dominant. This modifies the average quark mass in the loop of the gluon-fusion production, as well as the turn-on of the bbH production which comes with a recoil. Both have an effect on the Higgs pT, which becomes smaller at higher Higgs masses. These effects can be checked with SusHi, which calculates gluon-fusion production at O(alpha_s^3) and bbH production up to O(alpha_s). SusHi can be used to apply a reweighting of the SM samples for different tan β values.

Some further remarks:

VH@NNLO: Robert and collaborators are working on a consistent way to scale the calculation also at the QCD NNLO. The gluon-fusion contribution is proportional to the ttH coupling and needs a separate scaling.

VBF@NNLO: Fabio/Marco explained that for VBF the situation is slightly different. The quark-loop terms turn out to be much smaller than for VH, and can be safely neglected.

There was no progress on the **missing higher-order EW corrections** in the 2HDM. As we are so far setting only exclusions limits we might neglect them in the first approximation, however some rough idea of associated uncertainties would be great to have.

ToDo list:

- *Finalise benchmark proposals. For this we need to convert from the Higgs to the mass-eigenstate basis. Nikos agreed to follow up on this, with the help of Howard and Oscar.*
- *Two further interesting benchmark scenarios should be considered as well.*
    a. *The observed Higgs boson is the heavier one (H)*
    b. *The observed Higgs signal is due to degenerate states*
- *Proposal for the treatment of the missing higher-order EW corrections*

Probably the most useful would be to meet again soon, once Howard, Nikos and Oscar have a first concrete benchmark proposal.