Caterina Vernieri – Lecture 1 Questions

Questions marked in green were answered during the Q&A session. I haven't tried to correct grammar/spelling. Where a slide number was given it is shown.

Q1 (slide 14): What is the difference between m and m* in the figure? Difference between solid line and dotted.

A1: m* is defined as m$\gamma\gamma$bb - mbb -myy +250 , which is less sensitive to detector resolution effects than m$\gamma\gamma$bb.

Q2 (slide 14): How is single H a background to double H?
Why is HH-> bbbb not the channel most studied?

A2: H decaying to yy produced through gluon fusion, associated production with Z or ttbar are the main single H processing contributing to the event selection of yy+ 2b-jets.
HH to 4b is studied as well, as reported in the summary table of the results, it has a different s/b ratio compared to bbyy.

Q3 (slide 9): Are there ongoing or planned ttHH, WHH, or ZHH searches at the LHC?

A3: Not yet, as those production modes are further suppressed compared to gluon fusion. They will require larger datasets.

Q4 (slide 17, 18): Could you explain this plot in more detail? What is the significance of the 6.9 line shown here? Why is the pointed shape around (5,2) not visible on the next slide?

A4: This is the contour level of $\sigma(pp \rightarrow HH)/\sigma SM$ as a function of $\kappa t,\kappa\lambda$, under the assumption of no additional Higgs coupling vertices. The diamond indicates the SM predicted value. The reference values of 6.9 and 10 correspond to the best available observed and expected upper limits on the $\sigma(p\ p \rightarrow H\ H)$ cross section as measured by the ATLAS experiment with the 36/fb.

Q5 (slide 17): what does sentivity to k lamda from HH is reduced if coupling to top quark is left free to float mean? what does reduced mean?

A5: That the range you derive on the allowed values for klambda is larger in case you allow the top-Higgs couplings to differ from the SM value.

Q6 (slide 17): Why extraction of k_landa costrations from HH production is impossible without assumptions on k_t?
In addition, what are the assumptions on k_t?

A6: By assuming that new physics only contributes with anomalous values of the self-coupling (klambda =!1) we are basically assuming that all the other couplings (in particular the top-higgs yukawa coupling, kt =1) are set at their SM value.

Q7 (slide 14): Confused about something basic: What is X here? The thing that decays into the Higgs? If so (looking at earlier triangle diagrams), if X were the SM Higgs, wouldn't the peak of the bbyy invariant mass be at 125 GeV? Is that decay (SM Higgs to two SM Higgs) just not being considered for some reason?

A7: X here is a hypothetical new particle decaying to HH. So M_X = m$\gamma\gamma$bb

Q8 (slide 22): This figure suggests ttH has the greatest sensitivity. Does the conclusion stay the same if we include uncertainties that are different between channels?

A8: Yes, as shown in the plot on s23. Things will change if the kinematic information is available as well.

Q9 (slide 29): What is the physics reason for the double minimums in the plot?

A9: There is not enough information provided to the likelihood to distinguish different klambda hypotheses. If mHH were to be used the double minimum degeneracy would be lifted. As one can see by comparing the CMS vs ATLAS bbyy result reported in Fig 65 in arXiv:1902.00134

Q10 (slide 37): Can HE-LHC/FCC-hh measure single Higgs precisely?

A10: Higher energy could bring more precision especially to study the ttH production mode, for a complete comparison between the expected precision for single H processes at future colliders, please see https://arxiv.org/pdf/1905.03764.pdf