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Minutes of Heavy Higgs - BSM Group (15 November 2013)

Link to the [[http://indico.cern.ch/conferenceDisplay.py?confId=282374][agenda]]

CMS 2HDM status and needs

Comments:

- The VBF cross section in the 2HDM is expected to scale as cos^2(beta-alpha) at the tree level. This is true also if one considers QCD corrections. EWK corrections might be a small effect on top of this, but this needs to be checked. We should come up with a prescription for systematic uncertainties on this rescale, and put this information on the twiki. A similar reasoning can be applied for the VH cross section.

- As far as the pT distribution and uncertainties in 2HDM, Alessandro Vicini is working on a POWHEG implementation of the model. Experiment contacts are in touch with him. The timescale should be fast, they would like to show some preliminary distributions in about a month. The authors will keep in touch with the experiment contacts to test the code, as soon as they have a beta version.

- Setting the mH+ and mA parameters to very high values can be problematic. The problem is that setting these two masses high (while leaving mH low) can potentially introduce large quartic couplings (even non-perturbatively large) if not done in a controlled way. These large couplings could then affect, for example, the decay mode H->hh (which is important for H phenomenology), but also introduce non-decoupling effects in the couplings hH+H- and HH+H- (which enter in h/H->gamma gamma).

2HDM ATLAS update

- Both mA and mH+ have experimental constraints that impose their masses to be >~ 170 GeV, so below this threshold it doesn't make a lot of sense to impose them to the same values as mH. Nevertheless, one has to consider that these constraints are mostly valid for high tanbeta and Type-II 2HDM only. Scanning the high tanbeta region may be anyway problematic, especially for analyses with jets in the final state: if the coupling to bottom is greatly enhanced, analyses have to struggle with an increased number of jets in the signal final state that may require a complete redoing of the analysis.

- Considering the H -> hh decay, the continuum interference can be assumed to be very small. There is nevertheless the interference between the box and the triangle diagrams that needs to be taken into account

2HDM Theory recommendations

Summary of recommendations:

- 2HDM Higgs decays: 2HDMC and HDECAY
- gg : SusHi [elw. light fermion] and HIGLU
- b b production: SusHi [5FS] and MSSM grid [4FS] Santander matching
- SusHi linked to 2HDMC
- HIGLU linked to HDECAY
- following shortcut approaches are invalid,

- simple coupling rescaling in 2HDM,
- neglecting bbh contribution (in Type-II in particular) ,
- common NNLO K-factor for top and bottom contributions.

A0 -> ttbar progress

Q: The size of interference depends on Gamma. How large is Gamma? What lineshape did you use? A: The width is fixed by the model. To give an idea, for a 400 GeV state the width is around 3-4 GeV and for a 800 GeV case the width becomes 40-50 GeV. The theoretical shape dependence on Gamma is a function of s.

Q: How large is the gain in generation speed? A: It takes ~ 50 minutes to generate 500k events. It takes about a day to gave a statistics large enough to perform a meaningful subtraction of |S+B|^2 with |B|^2

VBF interference with Phantom and Madgraph

In order to have a coherent approach in the systematic uncertainties determination for VBF interference, the authors are suggested to get in contact with the g-g and VBF subgroups. One has anyway to consider that the QCD part of the uncertainty is not applicable here.

Minutes of Heavy Higgs - BSM Group (9 September 2013)

Link to the [[http://indico.cern.ch/conferenceDisplay.py?confId=270897][agenda]]

Alternative 2HDM cross section computation in CMS

Comments:

- HIGLU and ggH@NLO were used to get the cross-section estimation. In general, the group strongly recommends to use SusHi+2HDMC to get cross sections and BRs. ggH@NLO doesn't contain NLO QCD corrections for bottom quarks, and in general SusHi has the 2HDM fully implemented, so the results are the most reliable at this moment
- pT reweighting: K-factor for top and bottom quarks are largely different. Bottom quark contribution becomes very important for large tan(beta) in MSSM (Type-II in 2HDM) and bottom quark has softer spectrum in Higgs pT than top, thus would modify the acceptance. Therefore SM MC reweighing would be necessary at least with Higgs pT spectrum. Soft-gluon NNLL correction could be similar to SM, but the suggestion is to consult Higgs pT experts like Massimiliano Grazzini, Pietro Slavich, Alessandro Vichini, et al. on Higgs pT spectrum in 2HDM and associated uncertainties.
- NNLL QCD corrections for A0 are currently unknown

First studies with+2HDMC in CMS

Two possibilities for a definition of a benchmark point are discussed:

- One is to give a "fixed" benchmark point, fixing mA, mH+, tanbeta and sin(beta-alpha). Then provide cross sections and BRs as a function of mH
- The other is to give a "floating" benchmark point, expressing also mA, mH+, tanbeta and sin(beta-alpha) as a function of mH

Kostya also implemented a web tool to inspect the parameter space in 2HDM I and II:
http://kkanishc.web.cern.ch/kkanishc/2HDM/home.shtml

Comments:

- SusHi+2HDM provides pT spectrum at LO only. So it is proper to use it only for high pT Higgs

Implementation of 2HDM in HDECAY

It should be now ready to compare between 2HDMC and HDECAY, especially useful for H -> ZZ*

The main differences wrt 2HDM are:

- 2HDM: S -> g g to O(alpha_s) in the heavy quark approximation
- HDECAY: S -> gg at NLO QCD exact (with mass dependence), at NNNLO for the top quark loop in the heavy mass approximation

Update on VH@NLO in 2HDM

This proposal looks very promising for the 13 TeV run. At lower sqrt(s), the cross section for associated production is greatly diminished, but it is interesting to explore anyway.

Minutes of Heavy Higgs - BSM Group (26 June 2013)

Link to the agenda

Higgs (or physical) basis and implementation in Sushi+2HDMC

The Higgs basis is fully worked out for the CP conserving case with h126 as light 0+ state and it is under implementation in Sushi+2HDMC

Comments:

- in the Higgs basis, asking for Z_i<1 should be enough to enforce unitarity/perturbativity
- next generalization: CP not conserving case, h126 the high mass 0+ state
- implementation in 2HDMC will be transparent: can be used as the other basis
- CMS and ATLAS can play with 2HDMC+Sushi even now (Higgs basis still under development but other basis available)

Scan of benchmark points (Summary of discussion of 18 June)

- If all masses forced to be the same then only s(b-a) very near 1 is possible
- allowing masses to float (splitting between charged Higgs mass and heavy 0+ mass) then also small values of s(b-a) are allowed (with low tab no fine-tuning is needed)
- observation of h126 suggest large s(b-a) but the uncertainties on signal strenght are large and experiments want to keep an open-mind approach:
    1. identify which region of parameter space makes sense theoretically (unitarity constraints etc...)
    2. inject the knowledge of h126 observation considering the mass only
    3. inject the knowledge of h126 observation considering the mass and the signal strenght (still large uncertainty at 3 sigma level)
- the identified benchmarks should then be related to the experimental parameters (eg, width) and BR for decays (eg H->hh)
- We will have to consider not only xsec*BR but also how the kinematic will change. Also we need MC for specific decays eg H->hh

H/A->ttbar

- phenomenological work on-going to describe properly interference effects with background
    - in 0- case total width is ~equal to ttbar width
    - also when ttbar width smaller than total width (eg 0+) still large interference effects
    - interference will also have an effect on total normalization
- first experimental study on these effects started in CMS -> suggestion to move to NLO tools

Minutes of Heavy Higgs - BSM Group (15th May 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(\x{03b2} − \x{03b1}) 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 \x{03b2}. At high values of tan \x{03b2} 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 \x{03b2} 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.

Minutes of Heavy Higgs - BSM Group (30st April 2013)

Link to the agenda

Introduction

Brief recap of scope of the group and recipes ready for the SM case and work on-going on SM VBF and BSM (EW-singlet and 2HDM).

Comments:

- Once we agree on common recipe we should have a repository with actual numbers stored to be shared between ATLAS and CMS
  Work already on-going (see here):
  - WW results from ATLAs and CMS under comparison,
  - ZZ->2l2n only from CMS for now,
  - ZZ->4l provided by Giampiero (will be cross-checked with gg2VV)

EW-singlet

Bounds on parameters space from theoretical study and some ideas on EWK corrections

Comments:

- Is sinAlpha enough to describe the model? Why also tgBeta mentioned?
  tgBeta enters in H->hh couplings and H self-couplings, all second order effects
- Limits on signal strength of h126 from experiments should be considered taking twice the error (roughly equivalent to 95% CL). Most of the limit plots for that case are already shown in the paper (just Gamma-k plane missing but can be easily done). At low mass this doesn't matter (limits from perturbativity more important than limit due to measured h signal strength)
- H->ttbar may be modified (at the order of 10%) by loop with h [tbc, just raw estimate]
- How perturbative unitarity has been imposed? Just asking VV scattering to not explode (there are more complicated methods). Actually the fastest divergence comes from H->HH
- Some symmetries imposed to write the potential, how much general and how removing them would change the limit shown here? What if operators which violates FCNC at small level are included? z3 symmetry studied by other authors [JCAP 1301 (2013) 022].
- Question: is the naive estimate Gamma_tot/m_H as an error you make in the narrow width approximation correct (ie if you do the "correct" calculation w the complex pole scheme, is the error much larger/ smaller than the estimated one wrt the nwa ?). (Answer offline: yes the CPS results can be outside the narrow width uncertainty given by Gamma/mH, see for instance slide 5 of first talk)

NNLO gg->WW with soft-collinear approximation

gg->WW S+B+I computed at NNLO with soft-collinear approximation

Comments:

- main approximation comes from integrating out top and bottom mass in the loop (in cbar terms). In the Higgs case cbar~11 with mtop to infinity, cbar~11.47 - 6.57 for mh 480-720 with correct mtop. Uncertainties computed by considering +/-5*cbar, how uncertainties change with different factors in

front of cbar?
    - +/- cbar -> ~1% uncertainty
    - +/- 5 * cbar -> ~8% uncertainty
    - +/- 10 * cbar -> ~15-20% uncertainty
    - these are just the uncertainties related with cbar (eg, total uncertainty in the first case is 5%)
- is this computation reliable for exclusive analysis in different jet bins? No, approximation does not describe well the kinematic of the additional partons
- similar calculation for qq->WW on-going

Minutes of Heavy Higgs - BSM Group (22nd March 2013)

Link to the agenda

The main topic of this meeting was to discuss how ATLAS and CMS can explore the best way searches to the generic two Higgs doublet models (2HDM). As the parameter space is large, some simplifications/benchmarks are desirable.

ATLAS presented recently an analysis where a direct search for H is done, while all the other Higgs masses are assumed to be large. The free parameters remain: mH, tan \x{03b2}, \x{03b1}. Exclusion limits were presented on the mH – cos \x{03b1} plane for given tan \x{03b2} assuming type I or type II 2HDM with the condition that the lightest CP-even Higgs boson is identified with the boson at ~125 GeV. For this analysis, the SM Higgs MCs were rescaled with 2HDM couplings (see below for the description of the tools). In this approach one needs to be careful how the SM kinematics gets modified, especially from the bbH contribution. This is more of an issue at high tan \x{03b2}, the ATLAS analysis applied b-tag veto to minimise this problem. In general, a more quantitative assessment of possible biases could be done with an MSSM bbH MC sample. Top and bottom loop contributions can affect the HpT as well, though this should be a smaller effect, it would be nice to estimate this in the future. Currently, the H width is taken in the narrow width approximation. Since the h@125 GeV couplings to the W/Z are SM-like, the H width should be small, however it can be broadened above 250 GeV by H\x{2192}hh (needs to be quantified).

Further constraints on the 2HDM parameter space could be set by taking into account the diphoton decay rate of the observed boson at ~125 GeV.

The main available tools for a search of H in the 2HDM scenario are SusHi and 2HDMC.

BR calculation

2HDMC [CPC 181 (2010) 189] is a general-purpose calculator for the two-Higgs doublet model and can be used to calculate all 2HDM BRs and width for any parameter at tree
level for the CP-conserving scenario. Off-shell effects (e.g. h(125)\x{2192}ZZ\x{2192}4l, HÂ±\x{2192}tb) are not yet fully included in the program, however this is being implemented.

Cross section calculation

SusHi [CPC 184 (2013) 1605] is a program for the calculation of Higgs production in gluon fusion and bottom-quark annihilation in the MSSM (and SM). If the squark and gluino couplings are switched off, SusHi can be used to calculate general 2HDM cross sections. The program provides exact NLO QCD corrections and NNLO QCD corrections in the heavy top quark limit which are valid for mH < 2 mt. EW corrections are not applicable in the 2HDM scenario and have to be turned off.

The VBF and VH productions in the 2HDM can be estimated with the VBF@NNLO and VH@NNLO programs running at the NLO level and then rescale the cross section using the 2HDMC program.

Full higher-order EW corrections are not available in the 2HDM for any of these production modes. For now, the recommendation is to use only an uncertainty for the missing EW corrections. For the gluon-fusion production this could be the EW contribution from the light-quarks only which can be calculated with SusHi. For the other production modes the uncertainty can be taken as the magnitude of the SM EW corrections (until a better recommendation is found).

Benchmark choices

Further suggestions of 2HDM benchmark choices: take mh~125 GeV as an input and scan over values of |cos (\x{03b1}-\x{03b2})| vs tan \x{03b2} for benchmark choices of \x{03bb}, \x{03bb}A and \x{03bb}F (linear combinations of the Higgs self-couplings). While |cos (\x{03b1}-\x{03b2})| should range from 0 to 0.5 (corresponding to a very rough SM-like h), tan \x{03b2} could be taken as 0.5 < tan \x{03b2} < 50. An alternative would be a 3 parameter scan over cos (\x{03b1}-\x{03b2})|, tan \x{03b2} and mH and choose benchmark values for \x{03bb}A and \x{03bb}F. Different parameterisations can be mapped to each other with the 2HDMC code.
There was a short discussion on the null hypothesis for the experimental searches. The overall agreement was that for the moment this could be the SM, while the 2HDM scenario is the test hypothesis.

items for the nearer future

- Extend consideration to type III/IV benchmark models and charged Higgs searches, as well as to the scenario where the boson at 125 GeV is the heavier Higgs H
- Provide cross section / BR tables linked from the LHC HXSWG (Nikos Rompotis started to work on this already)
- Could ask the authors of VBF@NNLO and VH@NNLO to include the 2HDM couplings in a more formal way
- Discuss further the best way how to implement or access the uncertainties due to the missing higher-order EW corrections
- Quantify width effects at higher masses due to H\x{2192}hh decays
- Quantify kinematic biases compared to the SM expectation in different regions of the parameter space
- Consider the contributions of additional new degrees of freedom (scalars, fermions, vectors) to the H production

Minutes of Heavy Higgs - BSM Group (8th March 2013)

Link to the agenda

Introduction: status and plans of ATLAS/CMS for Heavy Higgs and EW-singlet

Comments:

- SM exclusion up to 1TeV with CPS from ATLAS shown in Moriond. 2HDM analysis on-going in ATLAS (what about CMS?)
  Problem of communication between this group and the experiments
  (2HDM ATLAS work should be presented at the next group meeting)
- EW singlet: is it really in the plan of ATLAS? Yes, even if right now there is more interest on 2HDM
  - 2HDM should be more comprehensive but also much more difficult to work-out theoretically (especially at high mass)
  - for 2HDM at low mass is SUSHI enough as XS and BR calculator? (Specific for MSSM, needs to be investigated for general 2HDM case)
  - need to have a dedicated 2HDM meeting
- At high mass to have in BSM the same precision as SM (NLO) a lot of work needs to be done
  - EW singlet is the first step. It can be done by Fall if proper manpower, proper organization and interest from the experiments
  - 2HDM it is more difficult and it may require more time: at NLO the scaling is not anymore uniform but you have different scaling for each diagram

CMS WW->lnjj: proposal for a LO EW-singlet interpretation at high mass

Comments:

- Why you rescale the SM signal width instead of just using LO BSM gg2VV or MCFM shape?
  - the only processed MC we have is Powheg so we need to reweight that
  - for signal lineshape we would like to keep the CPS which is much better than running BW approach
- There are 3 interference terms to consider |S_h+S_H+B|^2 = S_h^2 + S_H^2 + B^2 + I_hH + I_hB + I_HB
  - I_hH expected small if the 2 resonance have small width and far away
  - I_HB is exaclty what is addressed by the reweigthing schema using MCFM or gg2VV
  - I_hb should be checked: how much the gg->VV background at high mass is affected by the presence of low mass h ? (Typical problem in VBF case, expected small in ggH)
    Test it by comparing B only production and S_h+B production in MCFM and gg2VV
- Main caveat: we reweight QCD NLO MC with interference correction at LO. (QCD NLO effects on pT expected to be the same in SM and EW-singlet case)

CMS ZZ->llnn: proposal for a LO EW-singlet interpretation at high mass

Comments:

- Same recipe as lnjj in previous talk: in particular, full BSM line shape from LO MC is in reasonable agreement with SM LO lineshape rescaled
- The SM uncertainties obtained by applying different k-factors to interference term cannot be applied here -> let's start with 100% uncertainty on the interference correction
- 2D plot of upper limit can be produced in 3 ways
    - C' vs BRnew
    - C' vs width (slightly better, more easy to reinterpret in other models)
    - BRnew vs width and xsec exclusion on the z axis:
        - difficult to interpret you cannot know where the EWsinglet is really ruled out (ie UL<1)
        - misleading because far away from UL=1 (ie far away from xsec= EW-singlet xsec) the reweigthing schema do not work so we are not really excluding any well-defined xsec
- Formulas provided for EW-singlet to rescale couplings and width is valid only in the ZWA approximation. Implementing instead the model in gg2VV and MCFM should includes all the off shell propagator effects (no way to include those in a simple formula)

General discussion about plans and YR3

Lines of work:

- High mass SM case:
    - ggH theoretical inputs fine, still work on the experimental side to fully implement it
    - VBF to be worked out (hopefully some proposal from CMS in the next weeks)
- EW-singlet
    - reasonable LO strategy discussed today
    - a NLO precision can be reached by ~Fall -> we should contact the BR group immediately to ask to implement it in Prophecy4f (G.Passarino and C.Grojean)
- 2HDM
    - low mass at LO: ATLAS has some preliminary work on-going, will be presented at next meeting and hopefully documented in YR3. We should also contacts theoreticians involved in 2HDM and ask to present at next meeting (K.Peters)
    - high mass and NLO needs more work. Similar problem as in the SM case but mroe complex:
        - plan to implement it in gg2VV (N.Kauer)
        - EWK correction at NLO to be computed analytically (G.Passarino/all)
- VV scattering: we should start to discuss how to organize the work during LS1
  Proposal to start with mini workshop inviting experts (eg, Phantom authors)

Plans for YR3:

- Heavy Higgs SM case pretty well documented (contribution for VBF case can be added if study will be done in time)
- EW-singlet:
    - draft document has been circulated, it can be cleaned-up and included directly
    - CMS studies with MCFM and gg2VV can be added
- 2HDM: hopefully some preliminary studies from ATLAS (to be shown at next meeting)

Minutes of Heavy Higgs - BSM Group (23rd January 2013)

Link to the agenda

- Introductory talk with proposed strategy for BSM Heavy Higgs (SM Higgs with mixing with EW singlet) -> many questions in the slides. Summary of the discussion and open questions to follow up:
  - BRnew = 0 is something reasonable? Is the effect on the width of the decay H->hh negligible ?
  - QCD corrections in this BSM model are the same as in the SM (so same xsec uncertainty and pt spectrum)
  - EW corrections may be different but small wrt QCD corrections -> strategy for interference uncertainty with K and K' as in the SM is still applicable? Are K and K' different in this BSM models wrt to SM?
  - Interference is proportional to the total width so:
    - if BRnew=0, total width in this BSM model is equal to the SM total width, then S+I = S_SM * cosTheta^2 + I_SM * cosTheta
    - if BRnew>0 the total width will change wrt SM and I/S will scale differently
  - SM searches stop at 1 TeV (where mH/Gamma = 1 TeV / 0.7 TeV) -> Can we stop the BSM search at the mH/Gamma' = 1/0.7 as well? (in BSM we will have a different mH value for each width) (In SM 1 TeV is put as limit for unitarization constraints, the unitarization problems are pushed to higher values in this BSM model since the low mass Higgs performs already most of the unitarization)

- CMS talk with proposed strategy: rescale CPS lineshape with different width + interference from MCFM with different width rescales. Summary of the discussion:
  - interference reweighting:
    - plan A: uncertainty from K,K' rescaling as in the SM case
    - plan B: correct for interference from MCFM and put 100% uncertainty on this
    - plan C (not optimal): do not reweight for the interference, but put a limit equal the SM interference value that is the worse case. NB. It is not optimal since we know how much the interference is, so we should correct for it
  - we need the table of interference values for each value of width and mH (we can also just scale from the SM case as shown in slide 8 right, would be the uncertainty enough to cover the discrepancy between simple SM rescaling and proper interference computation?)

- ATLAS talk with general issues. Summary of the discussion:
  - the interference between gg->WW and gg->ZZ in same final state (lnln) needs to be better studied -> manpower!
  - the interference between VBF signal and VV scattering needs to be better studied -> manpower!
  - both the previous issues are under study in the SM case (and we have preliminary numbers/recipe), more studies are welcome.
  - in this BSM LHCXS working subgroup we are targeting very specific models which are direct extensions of the SM case so the proper recipe for the SM case needs to be implemented as first, both in ggF and VBF
    These specific models also have direct connection with the already discovered low mass Higgs -> common fit to low mass couplings and high mass search
    Generic and model-independent bump hunt (eg useful for graviton search) are outside the scope of the group.

Minutes of Heavy Higgs - BSM Group (12th October 2012)

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- proposal for HCP strategy presented and accepted: reweigthing for CPS and interference in mVV spectrum (see slides for full details)

- studies of interference effect in WW->lnjj: mWW reweigthing is enough to give the correct shape to other distributions (x-checked with MCFM)
  Uncertainty due to missing higher orders in interference are applied both to the mVV shape and to the total normalization

- proposal to study interference in VBF using Phantom and Madgraph.
  - We should also compare with VBF@NLO [full off-shell, only t-channel, but at NLO] [Andre will contact VBF@NLO authors]
  - We should also contact Dittmaier group which shown results about this in the past [Sara will do this]

Minutes of BSM and Heavy Higgs Meeting (27th July 2012)

This has been a meeting between the contact person to rump-up after the ICHEP rush and plan for the next open meeting (coming soon)

Interference for heavy Higgs:

- ZZ recipe settled, trying to develop a recipe for WW (see slides from Sara D.)
  - proposal:
    1. gg2VV generate S, B, S+B+I -> extract S+I by subtracting distribution of (S+B+I) - B
    2. rescale to NLO with k-factors from Passarino (already provided)
  - objection:
    1. the NLO affects more distributions than what a k-factor may describe
    2. interference is much bigger than in ZZ and it affects many distributions (while you extract S+I you can do only for one or few distributions at once) * answer:
    3. k-factor mainly affects pT (if w/o cuts) and it should be fine for inclusive case (we have to check for +1,2 jets) and if need to rescale more distribution we can contact the HRes people
    4. let's start looking at ggVV and MCFM and MC@NLO for additive case, compare and validate and then we go ahead from there * question: does CMS/ ATLAS simulate ggVV background or does it data-driven way? we need to have it simulated in order to implement any recipe
  - CMS: yes for H->ZZ->4lep, H->WW->lnln, not for semileptonic final states and H->ZZ->2l2n (to be checked)
  - ATLAS: the same

BSM

- Next step: define benchmarks compatible with low mass observation. Discussion:
  - in models where the low mass Higgs unitarizes only partially the VV amplitude, there is an heavier resonance which share the couplings to VV. This heavier resonance must interfere with VV similarly to the SM case (but interference suppressed wrt to Heavy SM Higgs as couplings suppressed)
  - Useful things to discuss at next open meeting:
    1. update from the theoreticians about sensible benchmark models after low mass discovery: should include heavy resonance cases as well as benchmark related with present and possible future measurements of the couplings for the observed low mass state (see below)
    2. report from experimentalist about plans for VV high mass searches (some activity in CMS)
  - The measuring of the observed resonance couplings is done in the LowMass group but they have a very model independent approach, we can be nicely complementary by proposing some specific models to test against the couplings measurement. (We should explicitly invite LM people at the next meeting)
  - Define benchmark is a nice thing but what about MC ? Experimentalists need MC for specific models in order to test them

VV scattering

To be handled in strict collaboration with VBF group.
CMS/ATLAS have interest in this but not enough manpower now for a full analysis

Minutes of Heavy Higgs Meeting (7th June 2012)

Summary about lineshape

- Inclusive Xsec
  - ggF numbers at 8 TeV with complex pole included are ready
  - ggF numbers at 7 TeV with complex pole included will arrive soon
  - effect on VBF xsec is taken into account from M>300 GeV for 8 TeV.
  - the residual theoretical uncertainty just due to line shape is much smaller than PDF and scale uncertainty (we will neglect it)
- Higgs mass lineshape (valid for all final states)
  - central values with complex pole available here and also implemented in POWHEG routine to reweigh our MC samples
  - uncertainty up and down bin by bin also available here and to be applied as residual systematics for the line shape
  - this applies both to ggF and VBF

Interference for H->ZZ

- Inclusive xsec: effect has been proven to be very small (<1%) just neglect it
- Effect on mH shape is much bigger (constructive below the peak and destructive above the peak). Let's define K=signal NNLO / signal LO. We have 3 approaches to include NNLO effects into signal, in presence of interference:
  1. multiplicative: (S+I)*K + B
  2. additive: S*K + I + B
  3. intermediate: S*K + I*K' + B Where K' is the square root of (signal NNLO/ signal LO) but considering only the gg initiated final states (not qg or qq). THIS IS NOT SUPPOSED TO BE A CORRECT COMPUTATION, this is just something reasonable which is always in between the other two approaches by construction

THIS IS THE ACCEPTED RECIPE

-
  - central values from the intermediate recipe (the bullet 3. above)
  - uncertainty are taken as the FULL ENVELOPE of multiplicative and additive (i.e. the full difference btw bullets 1 and 2 above). This corresponds to take 100% uncertainty on the K factor used to scale the interference
  - the full list of numbers is mh400, mh500, mh600, mh700, mh800
  - example of some plots with line shape and uncertainty band here

Comments/discussion

- the important point is to take the full difference btw multiplicative and additive as uncertainty. Then we have a good degree of belief that the "right" answer is in between them. Let's take the intermediate recipe as central value just as a reasonable approximation.
- on top of this we will need to check the effect of the NLO effects on the interference for the full kinematical distributions (not only the line shape but all the others distribtions). The effect is expected to be small in 4lep analysis, this should be checked but doable only after ICHEP

Interference for H->WW

- the interference has been proven to have huge effect both on xsec and on all the kinematical distributions

- the only way to check/correct for it would be to run gg2WW or MCFM
- we will never be able to do it in time for ICHEP
- SO THIS IS THE ACCEPTED RECIPE: let's stick to the 2011 recipe, i.e. we put a huge uncertainty on the xsec computed as 1+ (1.5*MH/TeV)^3 AND WE STOP THE SEARCH AT 600 GeV AS LAST YEAR

Minutes of Heavy Higgs - BSM Group (11th May 2012)

Link to the agenda

BSM

Doubly-charged Higgs. See slides for an overview of the status. Comments:

- the bound on vev is not strict (cancelation between different contributions to Delta rho are always possible), the VBF xsec should be parametrized as a function of vev
- Next step:
  - experiments should define their interest in expanding this search and present the needs/proposals at the workshop 24-25 May to get feedback from theoreticians
  - the proposal will be prepared/discussed in dedicated BSM meetings btw the relevant contact person and the interested analyzers
- ATLAS plan: paper with fiducial xsec in multi lepton and then conference notes on specific models

Fermiophobic Higgs. See slides for a proposal of benchmark

- basic/simple FP model in not fully consistent/valid as specific model.
- proposal is to have parametrization of the relative couplings with fermions and with bosons with reasonable boundaries as a function of mH. This should be the simplest toy model which is fully consistent (e.g., radiative corrections may be computed)
- the coupling of the charged Higgs to gamma gamma should also be taken under control
- similar parametrization proposed in the paper from Azatov et al [arXiv:1202.3415] and Espinosa et al [arXiv:1202.3697] (a=coupling to V, c=coupling to f and then a=c=1 is SM while a=1 and c=0 is simple FP). In the slides the explicit relation btw these 2 parameters is shown and a way to bound them to realistic values as a function of mH
- these modified couplings have been implemented in hdecay and the code, once validated by the various people involved, will be made publicly avaiable

BSM items for 24,25th workshop

- double charged Higgs
- FP Higgs
- a0 (to be followed up with MSSM people)
- general inventory presented at the previous meeting to have feedback
- the various topics will be followed up in separate meetings with interested people

Heavy Higgs

Heavy Higgs: reweighing for lineshape

- Easy-to-use tool available to implement the complex-pole-scheme (arXiv:1112.5517) in powheg samples
  - this reweighing is orthogonal to the interference effects (it depends only on Higgs virtuality m). Can be applied on top of any interference-related reweighting.
  - the line shape affect also the total xsec. This can be recalculated with POWHEG itself or the NNLO+NNLL xsec can be corrected for the effect (in any case the NNLO+NNLL xsec

agrees with POWHEG xsec)
    - uncertainty on the total xsec due to lineshape uncertainty as well as shape uncertainty itself can be provided by Passarino. Should be easy to extend the POWHEG tool to include it.
- Experience of reweighing for lineshape in the VBF group
    - similar approach developed in the VBF group: starting directly from numbers provided by Passarino for the complex-pole-scheme to reweight HAWK (include EWK effects)
    - the plots of the shape (w/0 EWK corrections) agree with POWHEG but there is a mismatch in the overall xsec (to be followed up offline)
- The reweighting of POWHEG is very useful to recompute all the acceptance effects in the experiments. And having 2 tools allow further comparisons/x-checks
- The EWK corrections should be completely negligible in ggF and a global k-factor should good enough in VBF

Heavy-Higgs items for the May 24-25 workshop

- would be good to have some results from experiments (e.g., effect on acceptance) due to line shape rewieghting
- interference in ZZ->2l2n in gg2ZZ MC may be ready soon!
- summary of the 14-15 CERN workshop (to be prepared by Sara&Sara)

Minutes of Heavy Higgs - BSM Group (30th April 2012)

Link to the agenda

BSM inventory:

List of the present Higgs BSM searches ongoing in the 2 experiments. Comments:

- 4th generation: Babis comment: theory breaks when q' mass >500 GeV (and direct serach is excluding lower q' mass). Does it still make sense to consider this model?
- Doubly charged Higgs: signal k-factor is taken from NLO calculations (also in the ATLAS result, apologies for the confusion)
- Fermiophobic Higgs: only a benchmark model. Theoretically not well defined, need to discuss how this should be addressed by experiments.
- Searches for a light CP-Odd Higgs (dedicated MC is needed)

Review of the theoretical models. Comments

- All what is a "simple" extension of the SM Higgs should be dealed in strict collaboration with the "Properties measurement" group: the aim is to extract limits leaving floating as many parameters as possible and removing SM costraints wherever possible.
- Similarly, the SUSY Higgs is splitted between MSSM/BR groups and this BSM group (NMSSM, XMSSM, ...). We should try to setup a joint meeting in the next future.
- For next iteration:
    - ♦ list of detailed "needs" and open issue from experimentalists concerning the listed BSM analyses
    - ♦ list of theoretical models which are not looked at and suggestions how to present results in more general way (such that can be reinterpreted in different models)

Heavy Higgs

- We should identify list of high mass BSM models which are compatible with observed xsec limits. In parallel we can pursue an open-mind approach with a general serach for spin 0 or spin 1 resonance at very high mass.
- 2 stages:
    1. before any discover of light higgs
    2. after that (if any) Main aim should be to measure exactly the VV xsec (and in case 2) see if it is compatible with the presence of a light higgs boson)
- Heavy SM-like Higgs cannot exist without new physics

Lineshape and interference

- A description of the correct lineshape for signal has been proposed and it si available. Now is necessary to implement the interference in the same scheme (almost ready in aMC@NLO!). Alternative descriptions should come soon
  The difference in lineshape observed for different scheme should not be considered a theoretical uncertainty
- for VBF case everything is properly implemented in the WWjj and ZZjj production processes in VBFNLO

- MC@NLO: alternative approach based on effective theory which deals with resonant and not-resonant pieces in such a way to mitigate the gauge-invariance problems. This will allow to produce events and applying cuts.
- 2 approaches on the table. What if any of them is ready for ICHEP? Is it feasible to reweight separately for the lineshape and the interference effects?

Review of MC containing ZZ/WW interferences

gg2ZZ. Comments

- CMS collaboration is already using the code to produce massive amount of events
- BW with fixed width

aMC@NLO. Comments

- they can also implement the interference effects btw the 2 Zeds in the 4e and 4mu final state

MCFM. Comments

- No top mass in gg->ZZ computation so interference would not be reliable.
- The Seymour scheme developed for s->infinity may not be reliable for low value of s
- WW is ok (but not correct line shape) can be used to reweigh the distributions (but NLO effects on interference are anyway missing and they can be large as well)

-- SaraBolognesi - 11-May-2012

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