Minutes of the
LHC Higgs Cross Section Working Group Workshop
CERN, July 5-6, 2010

Monday, July 5, 2010

Morning opening session

1) Welcome

Chiara Mariotti opened the CERN workshop with welcoming words.

2) News from Overall Contacts

Reisaburo Tanaka reminded the mandate of the group, and discussed the news and the goal of the workshop.

ATLAS and CMS want to use most precise NNLO cross sections for 7TeV data Higgs analyses. Inclusive Higgs cross section and BR calculations are well advanced now, i.e. inclusive NNLO(+NNLL) calculations are ready for ggF, VBF, VH, and NLO for ttH. We also have the similar maturity in the MSSM Higgs calculations. However, we still have to come to the agreement on the QCD scale uncertainty for each process and PDF+α_s error definitions following (or not) the PDF4LHC recipe.

ACTION ITEM: we start to write the CERN Yellow Report on inclusive Higgs cross sections and branching rations. The overall contacts will circulate the concrete instruction soon on the contents to be discussed in the paper. The 1st draft should be ready by the next Bari workshop in November 4-5. We shall also collect all the important theory papers to be cited in the report.

Natural next step is to study the exclusive Higgs cross sections, differential distributions for Higgs signal, for example Higgs p_T, and cross sections with experimental cuts with help of NLO MC's. The new activity proposed is to study the theoretical errors for the Standard Model background processes that are relevant to Higgs. We shall also discuss the theory errors related in the data-driven method, for example qq/gg→WW/ZZ background estimation in H→WW/ZZ decay, or jet-veto in VBF H→ττ with the presence of UE events and QCD backgrounds. The question will be how one can estimate the theoretical error in data-driven background estimation. This will be a very good occasion to open the new horizon of our activity. We shall also discuss theoretical errors as well as experiment related errors (ex. theory error in data-driven method).

ACTION ITEM: overall contacts will coordinate how this new activity can be organized in our working group. We shall call for additional contribution from ATLAS, CMS and theory community.

Finally Reisaburo asked again to try to make use of SharePoint that is a powerful tool for communication. For common repository, we shall try SVN as it is the CERN standard. TWiki page shall be prepared for that. For future workshops, we have received several proposals for 2011, from BNL and LAL-Orsay/LLR-Palaiseau. Some of us felt that it is a bit too frequent to have our workshops, thus to have BNL workshop in spring/summer and LAL/LLR (Paris) in autumn 2011 was proposed.

ACTION ITEM: overall contacts will propose the vote for the place and time for the workshops in 2011.

Tuesday, July 6, 2010

Afternoon closing discussion session

The round-table discussion was animated by Chiara Mariotti and Stefan Dittmaier.

1) QCD scale and PDF+α_s error definition

Concerning the QCD scale uncertainty, the range of scan for the factorization and renormalization scales are different depending on each process, factor 2, 3, 4, … of the central scale. For PDF errors, we have the recommendation from PDF4LHC working group. However, no concrete agreement was made on the cross section central value (either midpoint of average), and associated its error (either envelope method or calculate correctly by taking into account correlations).

ACTION ITEM: we shall continue the comparison with PDF4LHCrecipe and with other methods, and shall come to the agreement as soon as possible.

During the discussion, the question on PDF and α_s error correlations between different Higgs production channels and the background processes (ex. ttbar, WW/ZZ, etc.) with different PDF sets was raised. Also the difficulty of the correlated error estimation with the envelope method was pointed out.

ACTION ITEM: we shall prepare the wish list on PDF and α_s error correlations between Higgs and backgrounds with different PDF sets. PDF subgroup shall study on this.

Again to use the common world average QCD α_s for different PDF sets was requested. It was decided that we shall form a group of experts to give the LHC community a "world average value of α_s" experts from, Lattice, EW fits, e^+e^- jets & event shapes, Tau leptons, DIS, HERA: jets, Tevatron: jets at high Q^2, Quarkonia, etc. A comment was made that the Standard Model cross section taskforce and MC generator group inside ATLAS and CMS should be informed and should coordinate this effort,

ACTION ITEM: overall contact will contact the experts and form the group.

2) Standard Model Input Parameter

A question was raised on the W-width. The current 2008 PDG world average is Γ_W=2.141±0.041 GeV (PDG) is inconsistent with the theoretically derived value (Γ_W=2.08872 GeV at NLO). It was suggested to use this theoretically derived value.

ACTION ITEM: update our SM input parameter TWiki page (already done).

3) Higgs Cross Section with Experimental Cuts

The question is to how to define the cuts in the calculations, which are matched to the experimental resolution. Sasha Nikitenko made the proposal on how to compare the experimental cross section with theoretical prediction in the absence of NLO generator.

ACTION ITEM: each subgroup will define the benchmark cuts agreed between ATLAS and CMS as soon as possible to start the work during this summer.

4) Data-driven Standard Model Background Estimation

In the Higgs analysis, data driven methods to estimate background are under study in order to verify the Monte Carlo and Theoretical predictions for the background processes as well as for the signal. In well-defined kinematic regions (defined by cuts typical of the Higgs analysis), some of the cuts are inverted to suppress the signal and enhance one of the background sources. In that particular phase space, data are compared with MC prediction and eventual corrections and systematic errors are extracted. Then following the theoretical prediction these corrections are applied to the remaining background in the signal region. From these procedures the uncertainty from the background is partially coming from the experimental cuts, and part from the theoretical prediction. As a first approximation the two contributions can be considered independent and thus be multiplied.

These uncertainties will enter the combination procedure of the Higgs results, i.e. the theoretical part will be considered as 100% correlated between the channel and the experiment, while the experimental part is not correlated between the different experiments. This group will try to determine these uncertainties.

Nikolas Kauer presented the gg→ZZ calculation that is the irreducible background to the H→ZZ signal. The discussion was followed by the presentations by Andrey Korytov and Bruce Mellado on the experimental aspects on the data-driven background estimation on ZZ and WW, respectively. The gg contribution is known at the 20% level and it amounts to 10 to 20 % of the qq→ ZZ contribution, depending on the center-of-mass energy. Discussion is going on the advantage and real feasibility to control ZZ from Z, or to rely on MC distributions and theoretical calculations.

Pietro Govoni announced the one-day workshop on the backgrounds on VBF foreseen in fall 2010 or beginning 2011. Cross-section of central-forward jets topology and energy flow in the central region are an example of common topics among theory and experiments. Frank Tackmann presented the results on inclusive central jet-veto in gg→H.

5) Theoretical and Experimental Error Assignment

The goal of the group is to come up with a detail list of central values and variation interval, uncertainties and correlations for the signal and for all the individual background. The fact that the background is estimated with data driven way (see above) will complicate the overall picture.

6) Beyond the SM/MSSM Scenario

We did not have enough time to discuss this, but we shall keep this item for further discussion.

Subgroups report:

1. PDF subgroup

There were two presentations in the PDF session. Joey Huston presented the results of the benchmark exercise that was carried out within the PDF4LHC group and outlined the interim prescription adopted by the PDF4LHC group for calculating cross sections and uncertainties at the LHC. In the benchmark exercise, cross sections for W^+,W^-,Z^0, (gg→)Higgs (at masses of 120, 180 and 240 GeV) and ttbar production were calculated at 7 and 14 TeV using the nominal central PDF from each group. In addition, the PDF and α_s errors were calculated using a variation of ±0.002 (for 90% C.L.; 0.0012 for 68% C.L.) around the central value. For common comparison, each group also calculated the benchmark cross sections at a common value of $\alpha_s(M_Z)$ of 0.119.

The cross section predictions for Higgs production agreed reasonably well among each other, but tended to differ by more than the 68% C.L. PDF errors. At least part of this difference can be attributed to the different values of $\alpha_s(M_Z)$ used in the fits, and the differences did tend to shrink so the 68% C.L. PDF errors overlapped (sometimes barely) when the common value of $\alpha_s(M_Z)$ was used.

The interim prescription can be found at http://ww.hep.ucl.ac.uk/pdf4lhc/PDF4LHCrecom.pdf and involves calculating LHC cross sections using CTEQ6.6, MSTW2008 and NNPDF2.1 PDFs, using the native values of $\alpha_s(M_Z)$ for each PDF (0.118, 0.120 and 0.119 respectively). PDF and α_s errors are to be calculated at the 68% C.L. (Note that for CTEQ this means calculating the 90% C.L. using the CTEQ6.6 PDF and α_s error sets and then dividing by the naive factor of 1.645.) PDF+α_s errors are to be added in quadrature for CTEQ and NNPDF, while the MSTW prescription is to be used for their PDFs. The uncertainty of the Higgs cross-section predictions is given by the envelope of the predictions using the 3 PDFs and their (68% C.L.) uncertainties. The central prediction is the mean of the three predictions.

An addendum for NNLO is to use the MSTW2008 NNLO prediction as the central cross section and to apply the envelope of uncertainties obtained from the above 3 PDFs at NLO to the MSTW2008 PDFs at NNLO. This involves roughly a doubling of the original MSTW NNLO errors.

Alessandro Vicini then presented the results of this exercise on the Higgs cross section predictions at 7 and 14 TeV, for both NLO and NNLO. At NLO, typically, the upper end of the envelope is given by MSTW2008/NNPDF2.0 while the lower end of the envelope is given by CTEQ6.6. He noted that this procedure effectively increases the α_s error as the different preferred values of α_s are used for the central predictions for each PDF set.

In the discussion:
- Several objections to the recommended envelope method were raised, but it was finally agreed that this is a temporary recipe that may be improved as understanding progresses, and no better alternative seems to be viable at present

-It was suggested that a common alphas value might be adopted by all PDF groups, either as a common preferred value, or at least as a reference for benchmarking purposes, with possibly two different values being recommended at NLO or NNLO. No consensus has been reached so far on this.

-The issue of the uncertainty on alphas was discussed: there was general consensus that at least a common acceptable uncertainty range on alphas should be agreed upon, and a task force will be set up to study this issue (as well as, possibly, the previous one).

-The dependence of results on the values of heavy quark masses was emphasized by many, and the proper definition of the heavy quark mass was discussed. It was agreed that this dependence will be studied within the PDF4LHC working group and the adoption of a common value of the heavy quark masses will be encouraged in that context

-The role of theoretical uncertainties was emphasized, specifically those related to missing higher--order corrections and estimated by renormalization and factorization scale variation. It was agreed that neglect of these in current PDF sets may lead to somewhat underestimating PDF uncertainties, and that scale variation studies will be performed within the PDF4LHC working group.

Finally, the PDF4LHC group communicated that an interim note is being prepared, which will discuss general features of PDF sets, the prescription, the benchmark studies, and the predictions for Higgs production (as well as W, Z, ttbar production).

2. ggF subgroup

Presentation

- Complete numbers for the inclusive cross sections coming from two groups (de Florian+Grazzini and Anastasiou+Boughezal+Petriello) were presented. Some numbers from an alternate study by Baglio+Djouadi were also shown. All three groups attempt to combine all known information on the Higgs cross section: top-quark terms, bottom quark contributions, and electroweak contributions. The three estimates are in very good agreement. The Baglio+Djouadi uncertainties are typically larger. The other two groups show excellent agreement in central value and error.

- It was pointed out that the experimental cuts strongly change the pattern of perturbative corrections, especially in the presence of a jet veto. The impact of such cuts should be carefully studied.

Discussion on uncertainties

-What is the error on α_s? Values come back from 0.1135±0.0009(theory) from the thrust distribution at LEP, to 0.1175±0.0015(theory) from the 3-jet rate at LEP and even higher. How do we account for this uncertainty in the Higgs cross section? One proposal from Baglio/Djouadi: include an additional +- 0.002 theory error to be included as discussed in http://arxiv.org/abs/1003.4266 . The group is waiting for a recommendation from the proposed α_s subgroup before changing the uncertainty recipe. As currently formulated, only the experimental uncertainties encoded in the MSTW 2008 grids are included in the group's gluon-fusion error estimate.

- Other sources of uncertainty include the use of the heavy-top EFT approach for the NNLO coefficient function; the uncertainty in the bottom-quark initiated contributions arising from the unknown NNLO correction; and the uncertainty in the electroweak terms. These were estimated to be ±1%, ±2%, ±1% respectively (and conservatively) by the group members. A recommendation was given by the group that these to be combined quadratically, not linearly.

- Some discussion on the definition of the scale error occurred. Djouadi pointed out that the separate variation of μ_R and μ_F in the Baglio/Djouadi study, as opposed to the restricted range $1/2<\mu_R/\mu_F<2$ used by the group members did not significantly increase the error estimate. Thorne asked if the scale variation by a factor of 2 around some nominal scale is an appropriate measure of uncertainty. It was pointed out that, using the central value $\mu=M_H/2$, the application of this procedure leads to an overlap of the NNLO prediction with the NLO error band.

Future directions

- The working group should discuss the impact of the α_s uncertainty on the inclusive cross section. A recommendation from the proposed α_s subgroup is awaited.

- Upon the adoption of a set of standard cuts, as discussed at the workshop, the subgroup should consider the pattern of QCD corrections on the acceptances.

3. VBF subgroup

Talks:

I) Talk on "Higgs production via vector-boson fusion at NNLO in QCD" by Sven-Olaf Moch
- description of NNLO calculation
- result: t-channel dominance requires low scale

Discussion:
x For fully differential distributions, does the factorization approach used still hold or does it break down?
- Should be no problem if it is known how to calculate DIS 1jet inclusive NNLO-corrections. This is work in progress. Effects should be small.

x Size of the QCD NNLO corrections are small (Order per cent to per mille). How do these small numbers relate to non-factorizable corrections? Can they be larger? How valid is the factorization approach?
- Very satisfying approximation, in VBF neither small nor large x-limit dominate, the full structure function has to be used.
Looked at size of true NNLO corrections coming from structure function approach. Different possibilities for scales (+variations), all very consistent.
Pentagons already have been calculated in QED, seen to be very small contributions.

x The actual number of the NNLO correction is small but is it possible that the uncertainty will be larger than the number?
- Here we have a small color-factor, so we think this is rather negligible, under further investigation.

x What happens with realistic experimental cuts, UE, hadronization, Jet-definition ... is this a danger to the result?
- This is a statement of convergence of the perturbation series, from the results a Q^2 scale is recommended, work on the effects of realistic analysis/differential distributions in progress.

x How to quantify uncertainty of "realistic analysis cuts" - comparison of Pythia, Herwig very big difference.
- Take more contrib. into account, parton shower, hadronization, etc..

II) Talk on "HAWK and VBF@NLO calculations at NLO" by Sinead Farrington
- developments in VBFNLO and HAWK
- inclusive results from VBFNLO and HAWK with pdf uncertainties and comparison between both codes

Discussion:

1) HAWK/VBFNLO comparison:

x Comment on VBFNLO/HAWK EWK-corrections: including comparison, both generators seem to agree very well
- Once next version of VBFNLO is released, we can include this

x Weiglein/Dittmaier: agreement should be better than 0.5%
(Denner: agreement within Monte Carlo uncertainty, which is only 0.5% for the present comparison?)

x Spira: include VV2H in comparison (can be included, since only inclusive xsec is considered)
- Currently somewhat limited in manpower, will include everything available

2) parton shower, underlying event, hadronization

x Kotykov: what could be done beyond comparing PYTHIA, HERWIG and SHERPA? How to evaluate their differences for this process?

x How to address questions of selection efficiency, hadronization, Jet-def, etc. The uncertainty for these steps is much bigger here than in the comparisons shown here

x Oleari: when using POWHEG no big differences arise between PYTHIA and HERWIG (apart from detailed structure of jets)

x what is the different between using POWHEG and Pythia/Herwig alone?
- 3rd jet is correct from NLO calculation, in standalone Pythia/Herwig version the 3rd jet is only correct in the collinear approximation so the shape, normalization etc. is wrong here.

There is a study by Zeppenfeld and the Alpgen-group investigating the 3rd and 4th jet for the VBF channel.

4. WH/ZH subgroup

* In G.Piacquadio's talk the small differences between V2HV (NLO QCD, by M.Spira) and R.Harlander's code (NLO and NNLO QCD) were mentioned with the comment that they are (for WH) due to different handlings of the CKM matrix, which is not included in V2HV. M.Spira suggested that the difference for ZH might be due to b-bbar initial states, not included in the Harlander code. This should be clarified soon.

* Moreover, the general question was raised whether a window for the variation of factorization and renormalization scales should be fixed by convention. Robert H. pointed out that a factor of 2 for rescaling the central scales seems to be too small to cover the uncertainty of NLO with respect to the NNLO computation. A reasonable common convention for all processes seems hardly possible, i.e. assessing theoretical uncertainties (which is more than mere scale uncertainties) should result from case-by-case studies.

5. ttH subgroup

Talk on ttH production @ LHC by Michael Spira
- overview of signal and background calculations @ NLO
- available LO programs: HQQ, Madgraph/Madevent, MCFM,...
- definitions of first goals of this working group
- to do list: finalize numbers for CTEQ6.6
  generate full PDF+α_s uncertainties with MSTW2008
  generate numbers for NNPDF
  generate full envelope of MSTW2008, CTEQ6.6, NNPDF
- differences between MSTW2008 and CTEQ6.6@LO (20%) and NLO (7-8%)
- K-factors close to unity for MSTW2008 and very small uncertainties due to α_s -> explanation?
  (in contrast to α_s uncertainties with CTEQ6.6)
- first NLO distributions for H, t, tbar with MSTW2008, CTEQ6.6: p_T, pseudo-rapidity and rapidity
- necessity of public NLO codes for ttH@NLO?
- interface to POWHEG?
- NLO effects on realistic distributions (e.g. W^+W^-bbbb)?

Discussion:
- small α_s uncertainties for MSTW2008:
  Thorne: new PDF fit for each α_s -> cancellations in cross-section?
- distributions:
  Pittau: study realistic distributions@LO -> get idea about effects
  Spira: already done and shown in Freiburg
- small K-factors with MSTW2008:
  Djouadi: small K-factor for MSTW2008 due to 7 TeV energy similar to Tevatron?
  Spira: Tevatron: qq initial state dominant, LHC: gg initial state much larger -> no explanation for small K-factor,
  does not explain difference CTEQ6.6 <-> MSTW2008
- POWHEG:
  Oleari/Nason: interface to POWHEG doable within a few days, need only a subroutine for the virtual corrections -> should be done

6. NLO MC subgroup

Experimental presentation

1. Brief Summary of the Th and Exp presentations of the NLO MC Effort

As contribution to the NLO MC effort, to be documented in a written report, that can be partially or totally contributed to the planned LHC Higgs XS Working Group reports, we propose to:

From the theory side:
a) Review the status of the publicly available MC tools that include either MEwPS or NLOwPS for each of the Higgs production channels, including BSM.
b) Promote and support the use of the best available NLO MC tools in the experimental groups **as the default tools to be used for analyses.**
c) To adopt common (th, CMS, ATLAS) benchmark analyses setups (minimal but realistic) for the most important signatures (production+decay) to validate/study signal and background systematic uncertainties.

From the exp side:
a) review the updated experimental search strategies and tools, with highest priority for the 7 TeV and 1/fb SM Higgs searches, but then extending to BSM searches and to higher energy and luminosities.

b) study, based on the latest developments in NLO MC tools the theory-driven (TD) uncertainties affecting both signal and background event yields and shapes, and ultimately the search sensitivity.
c) review and update methods to estimate background normalizations and shapes from data samples in control regions, and compare to NLO MC predictions, to extrapolate background predictions in the signal regions, while minimizing uncertainties. In this respect, while there are methods to test with data the NLO MC background predictions, there are (AFAWK) no methods proposed to attempt testing the Higgs signal predictions, using, for instance, physics measurements of processes “analogous” to those involved in Higgs production. This seems difficult at the moment, since the Higgs boson is the peculiar particle that we know and its production and decay processes will only be truly studied when the Higgs boson is observed. Nevertheless, we’ll also keep thinking to the question of testing experimentally Higgs production predictions, even before the Higgs signal is actually observed.
d) in view of these studies, that need to be carried on in close collaboration with the other LHC Higgs XS subgroups, we also suggest that it would be important to agree (i) among theorists on uncertainties in the NLO MC inputs (PDFs spread, alphas and QCD scale uncertainty, etc), (ii) among experimentalists on common baseline selections for the different channels, so to be able to quantify and produce baseline uncertainty values, and (iii) among theorists and experimentalists how to associate the generator level objects to

the measured objects (relatively simple for lepton, but more complex for jets, eg in jet vetoing or tagging)

2. **Discussion and recommendations**.

During the Q&A session the issue of an urgent need for an H or A + bb NLO MC tool was raised. This could be quickly achieved by combining the existing NLO calculations in the framework of the POWHEG box.

The importance of jet-vetos in all the Higgs searches was stressed and the need for a proper and reliable simulation that includes the shower and underlying event description highlighted.

The discussion about this proposal has taken place after the presentation, but also on the Discussion session on Tuesday July 6th and privately at CERN with Chiara, Rei and Giampiero after the end of the workshop. Overall people agree with the general plan. However, it is mentioned that for the Yellow Book to be delivered by the end of this year, the highest priority is to do total cross section studies and uncertainties. Differential studies on background and Higgs signal predictions are obviously important but may not be over by the end of this year and will be the focus of the next collective report, planned for next year. During the discussion session, in view of background prediction studies, it is mentioned that it could be useful to get in touch with the MB and UE established LHC working group, for the understanding of the MB production and tuning of the MC parameters.

7. MSSM Neutral Higgs group

5-flavour bbH production and gluon fusion @ LHC by Markus Warsinsky

bb -> H:
- PDF uncertainties of 5-flavour calculation of bb -> H
  (Harlander/Kilgore, bbh@nnlo)
- need to go to NNLO because of scale uncertainties
- PDF+alphas uncertainties at NLO:
  for the moment used same b-mass in bbh@nnlo for all PDFs
  looked at MSTW2008, CTEQ6.6 and NNPDF2.0
  MSTW2008 and CTEQ6.6 consistent
  NNPDF2.0 about 12% higher than other two
- PDF+α_s uncertainties at NNLO:
  compared MSTW2008 to ABKM and JR09
  quite good agreement
  all central values and uncertainties parameterized, can be used easily

ggF:
- included scale uncertainty in decomposition ansatz of σ_{tt}, σ_{tb} and σ_{bb}
  based on Higlu and ggh@nnlo
- PDF uncertainties with MSTW2008 in the making
- comparison with cross section prediction in FeynHiggs2.7.0.
  FeynHiggs uses a different approach based on correction factors
  to amplitudes, but this affects only the SUSY loop
  contributions, which are expected to be small in the considered
  m_h^{max} scenario. Large differences were observed, most likely
  due to a problem with the implementation of the k factors
  obtained from A. Vicini et al and due to interpolation
  uncertainties arising from a coarse grid. See discussion below.

4-flavour bbH production @ LHC by Michael Spira

- overview of 4- and 5-flavour schemes and their connection
- definition of the 4-flavour scheme: α_s and PDF with 4-flavours
  -> no b-PDF
- grids for scalar and pseudo-scalar Higgs in 4FS available (4-flavour
  MSTW2008)
- open problem: PDF uncertainties in 4FS? Recommendation of PDF4LHC?
- comparison 4FS <-> 5FS: reasonable agreement for $\mu=M_H/4$
  -> error bands overlap
  central values deviate by up to 35% for
  large masses
  looks different for other scales ($M_H/2$, $M_H/8$)
  -> no strong conclusions
- procedure for SM -> MSSM: rescale Yukawa couplings
  include Z-matrix and Δ_b corrections
  SUSY-QCD remainder small (<1%)
  scale choice for Δ_b: M_{SUSY}

- validity of Δ_b approximation: only successful so far for at least one on-shell bottom quark

  ggF: Δ_b approximation does not make sense before pure QCD and genuine SUSY-QCD are cleanly separated theoretically -> work in progress.

Discussion

The points raised in Markus' talk were discussed, using also the plots provided by Stefano Forte as additional material. This gave some informations about the deviations between NNPDF and the other pdf sets, which cannot be traced to the fact that NNPDF2.0 uses a zero mass scheme. However, it was found that the numerical input value for m_b plays an important role in this context. It was argued that the envelope method was indeed applicable here. The consensus was that the PDF group will look into this problem again. Meanwhile it turned out that NNPDF agrees with CTEQ6.6 in the bb luminosity when using 5 GeV for the b mass. Thus the variations of the PDFs due to the value of the bottom mass are significant and have to be taken into account consistently in the future. The b mass involved in the bottom Yukawa coupling has to be chosen according to the PDF set. A joint meeting with the PDF group about this b mass issue will be organized.

Concerning the request for 4-flavour error PDFs in Michael's talk, Robert Thorne promised them to be `soon' available from MSTW. The 4-flavour bbH calculation will take them into account for the PDF uncertainties.

Concerning ggF, one point was the comparison with FeynHiggs which was based on too few values for the grid to provide a reliable interpolation. The FeynHiggs authors received corrected values for the k factors from A. Vicini that are currently being implemented. This should enable a more meaningful comparison soon. They still need to work on a finer grid in order to reduce uncertainties related to the interpolation.

8. MSSM Charged Higgs group

The charged MSSM Higgs session comprised a talk by M. Kraemer on recent results of the four-flavour scheme NLO SUSY-QCD calculation. A second talk on the recent implementation of the 5FS calculation into MC@NLO (to be organized by one of the conveners, T. Plehn) was cancelled for reasons unknown to the other conveners.

The talk by Kraemer included new NLO 4FS results at 7 TeV with the standard choice of input parameters and the recent MSTW 08 four-flavour pdf. Here is a summary of the results:

- scale dependence: significantly reduced at NLO, central choice of scales is the average mass $\mu_0 = (m_{bottom} + m_{top} + m_{Higgs})/3$. Scale variation by a factor of three provides a conservative estimate of the scale uncertainty, as the NLO curve reaches a maximum at $\mu_0/3$.
- total cross section: slightly enhanced at central scale w.r.t LO prediction. K-factors range from 1.1 at $m_H = 200$ GeV to 1.2 at $m_H = 500$ GeV.
- the SUSY part of the NLO corrections can be described by a rescaling of the Yukawa coupling, as for the related process pp -> bbh; non-universal SUSY-corrections are negligible.
- NLO corrections soften the shape of the bottom pt-distribution.
- the comparison of the NLO 4FS and 5FS calculations does not show a satisfactory agreement: while the error bands overlap, the central predictions of the 5FS are about 40% larger than those of the 4FS. A better agreement between 4FS and 5FS has been observed in the process pp -> bbh where a NLO 4FS calculation could be compared to a NNLO 5FS calculation.

Outlook:

- the numerics for the 4FS calculation at 7 TeV has to be completed. Still missing is the pdf uncertainty and results for distributions and cross sections with cuts.
- a more systematic comparison between 4FS and 5FS calculations is necessary, including the impact of different choices of scales and the comparison of differential cross sections.
- given the problems of matching 5FS calculations with parton showers discussed at the workshop it was suggested to implement the 4FS calculation into Powheg to provide a tool that would be able to reliably predict differential distributions and exclusive observables.

9. Branching Ratios sub-group

1) Talk on "SM branching ratios" by Ivica Puljak
- strategy of calculation
- problem of inconsistent value for W width
- results for HDECAY and Prophecy4f
- to do list
  SM predictions practically ready:
  calculate on finer grid and publish

2) Talk on "MSSM branching ratios" by Sven Heinemeyer
- first code comparisons between FeynHiggs and CPSuperH
  for M_h and alpha_eff in mhmax and no-mixing scenarios
- ongoing comparision for BR(t->H+b) by Sami Lehti and Tuomo Hartonen
- plans: description of calculation for each relevant code and
  each decay width

Discussion:

1) interferences

Weiglein:	in some cases in MSSM interferences must be included and production x decay approach is not reliable
Spira:	Keep separation of production and decay in different working groups and merge afterwards, production and decay have different sources of uncertainty
Djouadi:	production x decay is ok in most cases that are not already excluded

2) overlap with MSSM groups

Heinemeyer: do not merge groups but coordinate in order to avoid doubling the work.

The `relevant' people (Spira, Weiglein, Heinemeyer) will coordinate this.

3) Input parameters:

There was an agreement that for the W width the calculated NLO value should be used in NLO calculations. In general, derived parameters should be calculated consistently within each calculation. Rei will make a proposal to the SM working group.