MSSM Neutral Higgs Tools and Plans for YR4

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Introduction

- The members of the Neutral MSSM subgroup:
  - Convenors: Felix Frensch, Stefan Liebler, Allison McCarn, Pietro Slavich , Michael Spira, Roger Wolf
  - Many Contributors: Emanuele Bagnaschi, Sven Heinemeyer, Gabriel Lee, Margarete Mühlleitner, Jérémie Quevillon, Nikos Rompotis, Trevor Vickey, Carlos Wagner, …
- Tools for Neutral Higgs:
  - Production of ROOT files for benchmark scenarios: Higgs masses and widths, cross sections including uncertainties, branching ratios.
  - Updated user-side access tools!
- Looking back at YR3 and plans for YR4

Cross Section and Branching Ratio Production

ggh + bbh 5FS MSSM Cross Sections

- ✓ Made with SusHi-1.5.0, interfaced with FeynHiggs-2.10.2
- ✓ For hMSSM, only SusHi-1.5.0 is used.

bbh 4FS MSSM Cross Sections

- ✓ SM cross sections are reweighted with the effective top and bottom couplings at each (m_A, tan(β)) point in the MSSM.

Branching Ratios

- ✓ Calculated using a combination of FeynHiggs, HDECAY and Prophecy4f.
- ✓ For hMSSM, only HDECAY is used.

Uncertainties

- ✓ Scale uncertainties from envelope of variations of μ_r and μ_f.
- ✓ PDF-α_s uncertainties from relative uncertainties of SM with m_ϕ using PDF4LHC prescription.

ROOT File Merging

New merging code is now available in svn! Main files/commands are:

mssm_xs_binning.py: Used to define binning in (m_A, tan(β)), example usage:
python mssm_xs_binning.py --mA-binning="127.5-1002.5:5" --tanb-binning="0.5-60.5:1”

main.cxx: Base code for merging the final root file, must be recompiled for any change in binning.

Basic run command is: ./runit.exe <scenario> <energy> <binning>

The final merged file includes:

- ✓ Higgs masses and widths.
- ✓ Gluon fusion (ggh) cross sections.
- ✓ Bottom-quark associated production (bbh): 4FS and 5FS, as well as “Santander matched” cross sections.
- ✓ Rescaling factors for 4FS cross sections.
- ✓ Scale and pdf-α_s uncertainties for cross sections.
- ✓ All relevant branching ratios.

Access Tools: Python

- The access tool for the user has also been updated, but the tools are still contained in the class ‘mssm_xs_tools.C/h’.
- There is now a python script, ‘mssm_xs_tools.py’ available that uses this class to easily print out information for a given m_A, tan(β) point!
- The files can be found on the MSSM Neutral twiki.

Python functions currently defined:

```
def mass(self, boson, mA, tanb)
def width(self, boson, mA, tanb)
def br(self, decay, mA, tanb)
def xsec(self, mode, mA, tanb)
```

Example Python Usages:

For H with m_A = 300 GeV and tan(β) = 3.

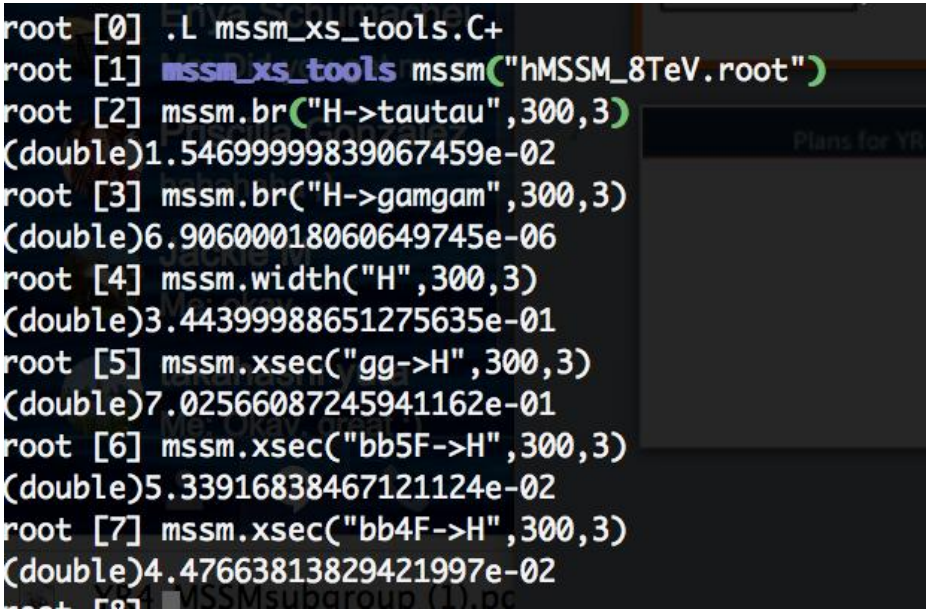
```
mssm = mssm_xs_tools("hMSSM_8TeV.root", True, 0)
mssm.mass("H”, 300, 3)
mssm.width("H”, 300, 3)
mssm.br("H->tautau”, 300, 3)
mssm.xsec ("gg->H”, 300, 3)
mssm.xsec (”bb5F->H”, 300, 3)
mssm.xsec (”bb4F->H”, 300, 3)
mssm.xsec ("bbSantander->H”,300, 3)
mssm.xsec ("gg->H::scaleUp”, 300, 3)
mssm.xsec ("gg->H::pdfasUp”, 300, 3)
```

Access Tools: ROOT

- For those who choose to stick with ROOT, the usual class has still been refurbished to be a little more intuitive.
- Values are accessed similarly to the python version.
  - The ‘old-style’ access functions are also still available and can be used with the latest tool.

```
root -l
.L mssm_xs_tools.C+
mssm_xs_tools mssm(“input_file.root")
mssm.br("H->tautau",300,3)
mssm.mass("H”, 300, 3)
mssm.width("H”, 300, 3)
mssm.br("H->tautau”, 300, 3)
mssm.xsec (”bb5F->H”, 300, 3)
mssm.xsec (”bb4F->H”, 300, 3)
mssm.xsec ("bbSantander->H”,300, 3)
mssm.xsec ("gg->H::scaleUp”, 300, 3)
mssm.xsec ("gg->H::pdfasUp”, 300, 3)
```

Example of actual usage with 8 TeV hMSSM merged file:



Plans for YR4

- Covered in YR3:
  - ✓ presentation of new benchmark scenarios (meanwhile heavily in use).
  - ✓ effects of NLO QCD squark contributions as implemented in SusHi.
  - ✓ detailed discussion of theory uncertainties.
  - ✓ discussion of resummed pT distributions through POWHEG implementation.

- Plans for YR4:
  - ✓ Extension of the hMSSM/low-tb-high note – more details on EFT comparison.
  - ✓ Description of the ROOT files for 13/14 TeV with new theory uncertainties and the new access script.
  - ✓ Comment on theory developments (N^3LO top, NNLO stop contributions, …)
  - ✓ Contribution to pT distributions by Emanuele Bagnaschi, Robert Harlander, Hendrik Mantler, Marius Wiesemann, Alessandro Vicini.
  - ✗ Your input?!