

proVBFH-inclusive v.2.0.2 manual

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This document provides a short documentation for the `proVBFH-inclusive` code.

1 Credits

The `proVBFH` program was developed by Matteo Cacciari, Frédéric Dreyer, Alexander Karlberg, Gavin Salam and Giulia Zanderighi and is based on

- M. Cacciari, F. A. Dreyer, A. Karlberg, G. P. Salam and G. Zanderighi, Phys. Rev. Lett. **115** (2015) no.8, 082002 [arXiv:1506.02660 [hep-ph]],
- F. A. Dreyer and A. Karlberg, Phys. Rev. Lett. **117** (2016) no.7, 072001 [arXiv:1606.00840 [hep-ph]].

When using results at next-to-next-to-next-to-leading order (N^3LO), the original references on third order coefficient functions should be cited as well

- A. Vogt, S. Moch and J. A. M. Vermaseren, Nucl. Phys. B **691** (2004) 129 [hep-ph/0404111].
- S. Moch, J. A. M. Vermaseren and A. Vogt, Phys. Lett. B **606** (2005) 123 [hep-ph/041.2.1].
- J. A. M. Vermaseren, A. Vogt and S. Moch, Nucl. Phys. B **724** (2005) 3 [hep-ph/0504242].
- S. Moch, M. Rogal and A. Vogt, Nucl. Phys. B **790** (2008) 317 [arXiv:0708.3731 [hep-ph]].

Finally, when evaluating cross sections for di-Higgs production the following reference should be cited

- F. A. Dreyer and A. Karlberg, Phys. Rev. D **98** (2018) no.11, 114016 [arXiv:1811.07906 [hep-ph]].

2 Installation/dependencies

To run `proVBFH-inclusive`, you will need an installation of the following packages:

- `hoppet`: <https://github.com/hoppet-code/hoppet>. At least v.1.3.0.
- `LHAPDF`: <http://lhapdf.hepforge.org/>.

With these installed, `proVBFH-inclusive` can be compiled by going to the base directory and running

```
./configure [options]
make
```

Available options in the `configure` script can be accessed through the `--help` or `-h` argument, as well as being described in the `INSTALL` text file.

We suggest that the references for `hoppet` and `LHAPDF` are also cited when using our program.

3 Setting up a run

To run `proVFBH-inclusive`, you can simply call the executable `provbfbh_incl` created by the installation steps above. All parameters are passed as command line options, with the full list of settings detailed in the section below, or accessible in `src/parameters.f90`. Since executing the code will produce several files, the recommended usage is to start individual runs in dedicated subfolders.

An example setup:

```
mkdir nlo-14tev; cd $_
../provbfbh_incl -nlo -sqrts 14000 -iseed 2
```

This will produce three files, two files `grids_0002.dat` and `grids_0002.top` containing the grid and an output file `xsct_nlo_seed0002.dat` containing the results of the run. Different seed numbers and orders in α_s can be executed in the same location, as they will result in distinct output files.

4 Dihiggs production

To run `proVFBH-inclusive` for diHiggs production, one needs to compile the `provbfbhh_incl` program with

```
make provbfbhh_incl
```

which can then be executed exactly like the single Higgs program to calculate the total cross section in VBF Higgs pair production.

5 Input parameters

All accessible parameters can be specified as command line arguments.

The available options, and their default value (in **bold**), are:

- `-lo`, `-nlo`, `-nnlo`, **`-n3lo`**: Order in α_s .
- `-sqrts` **13600**: Center-of-mass energy in GeV.
- `-scale-choice` **1**: Scale choice to use, with the options
 - 0: Fixed scale at $\mu_0^2 = m_h^2$.
 - 1: Vector boson momentum $\mu_0^2(Q_i^2) = Q_i^2 = -q_i^2$.
 - 2: Common scale given by $\mu_0^2(Q_1, Q_2) = Q_1 Q_2$.
 - 3: $\mu_0^2(p_{t,H}) = \frac{m_H}{2} \sqrt{\left(\frac{m_H}{2}\right)^2 + p_{t,H}^2}$ from 1506.02660.

- **-xmuf 1.0:** Factor x_{μ_F} multiplying the factorisation scale $\mu_F = x_{\mu_F}\mu_0$.
- **-xmur 1.0:** Factor x_{μ_R} multiplying the renormalisation scale $\mu_R = x_{\mu_R}\mu_0$.
- **-pdf PDF4LHC21_40:** Choice of PDF set (by name).
- **-nmempdf 0:** Member of the PDF.
- **-mh 125.:** Higgs mass.
- **-hwidth 0.00402964:** Higgs width.
- **-mw 80.398:** W mass.
- **-wwidth 2.141:** W width.
- **-mz 91.187:** Z mass.
- **-zwidth 2.4952:** Z width.
- **-nf 5:** number of quark flavours.
- **-mt 172.4:** top mass.
- **-mb 4.75:** bottom mass.
- **-readinggrid:** Use available grid if possible.
- **-higgsbreitwigner:** Use a Breit-Wigner propagator for the higgs.
- **-higgsmasswindow 30.:** Number of width to integrate around the BW peak.
- **-ncall1 100000:** Number of calls for the initialisation of the integration grid.
- **-itmx1 3:** Number of iterations for the grid initialisation.
- **-ncall2 100000:** Number of calls for evaluating the integral.
- **-itmx2 3:** Number of iterations for the integration.
- **-iseed 10:** Random seed.
- **-pdfuncert:** Compute PDF uncertainties on the fly. Significantly increases computation time (scales linearly with the number of PDF members). Also computes α_S uncertainty if this is included in the PDF.
- **-alphasuncert:** Separates the PDF and α_S uncertainty on the printout.
- **-3scaleuncert:** Compute 3 point (ie symmetric) scale variation.
- **-7scaleuncert:** Compute 7 point scale variation.