# Manual for Higgs boson production in association with top quarks in the POWHEG-BOX-V2

The ttH program in the POWHEG-BOX-V2 is an implementation of Higgs boson production in association a top quark pair. Details of the calculation are described in Ref. [1]. If you use this program, please quote Refs. [1–4].

## Running the program

Download the POWHEG-BOX-V2, following the instructions at the web site

http://powhegbox.mib.infn.it/

and go to the process directory by typing

```
$ cd POWHEG-BOX-V2/ttH
```

Notice that, in order to allow the use of a dynamical damping factor for high-$p_T$ radiation, the Bornzerodamp.f file has been modified. Since this is not general, but specific to the implementation of the ttH process, a local Bornzerodamp.f file is provided in the /ttH directory and can be linked directly from there. In order to use a damping factor, either hdamp or dynamic_hdamp have to be set in powheg.input. If hdamp is active the code runs with a fixed value of $h$ =hdamp in the damping factor for high-$p_T$ radiation ( damping factor = $h^2/(p_T^2+h^2)$), while if dynamic_hdamp is active it runs with a dynamic $h$ (defined in Bornzerdamp.f). Only one of the two parameters can be active.

Running is most conveniently done in a separate directory. Together with the code, we provide the directory testrun that contains sample input and seed files.

For your runs, generate your own directory, for instance by doing

```
$ mkdir myruns
```

The directory must contain the powheg.input file, where parameters for the Higgs boson and the top quark decays as well as technical parameters are specified, and, for parallel running, a pwgseeds.dat file (see manual-BOX.pdf and Manyseeds.pdf in the POWHEG-BOX-V2/Docs directory).

Before compiling make sure that:

- lhapdf is installed and lhapdf-config is in the path,
- gfortran, ifort or g77 is in the path, and the appropriate libraries are in the environment variable LD_LIBRARY_PATH.

After compiling the executable `pwhg_main` in the `ttH` directory, enter the `myruns` directory and perform all your runs there.

The program can be run in a parallel mode in several consecutive steps by setting

```
manyseeds 1
```

in the file `powheg.input`. With this option, the four steps of grid generation, NLO calculation, upper bound generation, and event generation can then be performed in parallel, consecutively, as described, for instance, in the manual of the `VBF_Z_Z` directory in the `POWHEG-BOX-V2`. Alternatively, all results can be obtained in the serial mode of the program by de-activating the `manyseeds` option.

If the default analysis is activated by setting the flag `ANALYSIS=default` in the Makefile before compiling the code, after the completion of the NLO calculation for each parallel run a file `pwg-*-NLO.top` is generated (where the * denotes the integer identifier of the run). These files contain histogram information at fixed-order accuracy for an inclusive setup in gnuplot-friendly format. The default analysis routine can easily be replaced with a personalized one by the user.

The events that are ultimately generated in Les Houches format can be processed by a generic Monte-Carlo program. We are providing interfaces to `PYTHIA 6.4.25` and `HERWIG-6.5.10`, respectively. After generating the exectuable `main-PYTHIA-lhef` (`main-HERWIG-lhef`) and running it in the directory where the event files are stored, the program produces an output file `pwgPOWHEG+PYTHIA-output.top` (`pwgPOWHEG+HERWIG-output.top`) that contains histograms at NLO+PS accuracy. The Monte-Carlo parameters can be modified by the user in the file `setup-PYTHIA-lhef.f` (`setup-herwig-lhef.f`).

## References


[1] H. B. Hartanto, B. Jäger, L. Reina, D. Wackeroth, *Higgs boson production in association with top quarks in the POWHEG BOX* , arXiv:1501.04498 [hep-ph].

[2] S. Dawson, L. H. Orr, L. Reina and D. Wackeroth, *Associated top quark Higgs boson production at the LHC*, Phys. Rev. D **67** (2003) 071503 [hep-ph/0211438].

[3] S. Dawson, C. Jackson, L. H. Orr, L. Reina and D. Wackeroth, *Associated Higgs production with top quarks at the large hadron collider: NLO QCD corrections*, Phys. Rev. D **68** (2003) 034022 [hep-ph/0305087].

[4] S. Alioli, P. Nason, C. Oleari and E. Re, *A general framework for implementing NLO calculations in shower Monte Carlo programs: the POWHEG BOX*, JHEP **1006** (2010) 043 [arXiv:1002.2581 [hep-ph]].