

# The POWHEG-BOX-hvq manual

## 1 Introduction

The POWHEG-hvq program can be used to generate heavy quark events (i.e.  $t\bar{t}$ ,  $b\bar{b}$  and  $c\bar{c}$  events) in hadronic collisions. It was first implemented in ref. [1], and then it was implemented again within the framework of the POWHEG BOX [2]. If you use this code, please quote [1] and [2].

This document describes the input parameters that are specific to this implementation. The parameters that are common to all POWHEG BOX implementation are given in the `manual-BOX.pdf` document, in the POWHEG-BOX/Docs directory.

## 2 Generation of events

Do

```
$ cd POWHEG-BOX/hvq
```

```
$ make pwhg_main
```

Then do (for example)

```
$ cd testrun-b-lhc
```

```
$ ../pwhg_main
```

At the end of the run, the file `pwgevents.lhe` will contain 1000000 events for  $b$  pair production in the Les Houches format. In order to shower them with PYTHIA:

```
$ cd POWHEG-BOX/hvq
```

```
$ make main-PYTHIA-lhef
```

```
$ cd testrun-b-lhc
```

```
$ ../main-PYTHIA-lhef
```

## 3 Input parameters

Parameters in `powheg.input` that are specific to heavy flavour production:

```
qmass 4.75 ! mass of heavy quark in GeV
```

The reference factorization and renormalization scales are taken by default equal to  $\sqrt{p_T^2 + m^2}$ , where  $p_T$  is the transverse momentum of the heavy quark in the underlying Born configuration (i.e. before radiation). If

```
fixedscale 1 ! use reference ren. and fact. scale = qmass
```

the reference scale is  $m$

### 3.1 Top decays

If the quark being produced is a top, which is automatically determined by the program on the basis of the value of the mass, the top decay may be driven by the flag

```
topdecaymode 20000 ! an integer of 5 digits representing the decay mode.
```

Top is assumed to go to a  $b$  and a  $W$ , with the  $W$  decaying according to a diagonal CKM matrix. The meaning of the token is the following: each digit represents the maximum number of the following particles in the (parton level) decay of the  $t\bar{t}$  pair:  $e^\pm$ ,  $\mu^\pm$ ,  $\tau^\pm$ ,  $u^\pm$ ,  $c^\pm$ . Thus, for example, 20000 means the  $t \rightarrow e^+ \nu_e b$ ,  $\bar{t} \rightarrow e^- \bar{\nu}_e \bar{b}$ , 22222 means all decays, 10011 means one goes into electron or antielectron, and the other goes into any hadron, 00022 means fully hadronic, 00011 means fully hadronic with a single charm, 00012 fully hadronic with at least one charm. The value 0 means that the  $t$  and  $\bar{t}$  are not decayed. Values that imply only one  $t$  decay (for example 10000) are not implemented consistently.

If the flag `semileptonic` is set to 1, only semileptonic decays are kept by the program.

In case `topdecaymode` is different from 0 more parameters are needed for the decay kinematics, and are used exclusively for decays

```
tdec/wmass 80.4      ! W mass for top decay
tdec/wwidth 2.141    ! W width
tdec/bmass 5         ! b quark mass in t decay
tdec/twidth 1.31     ! top width
tdec/sin2w 0.23      ! Weinberg angle
tdec/elbranching 0.108 ! W electronic branching fraction
tdec/emass 0.00051   ! electron mass
tdec/mumass 0.1057   ! mu mass
tdec/taumass 1.777   ! tau mass
tdec/dmass 0.100     ! d mass
tdec/umass 0.100     ! u mass
tdec/smash 0.200     ! s mass
tdec/cmass 1.5       ! charm mass
tdec/sin2cabibbo 0.051 ! sine of Cabibbo angle
```

If `topdecaymode` is not set, or is set to 0, then top decay is not performed by POWHEG. The event is passed to the Monte Carlo with undecayed tops, and the Shower program drives the decay. In this case, no spin correlations for the decay are included.

## Bibliography

- [1] S. Frixione, P. Nason, and G. Ridolfi, *A Positive-weight next-to-leading-order Monte Carlo for heavy flavour hadroproduction*, *JHEP* **0709** (2007) 126, [0707.3088].
- [2] 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, [1002.2581].