The POWHEG-BOX-WW manual

1 Introduction

The POWHEG-BOX-WW program [1] can be used to generate the QCD production of W^+W^- events in hadronic collisions, with the W-bosons decaying into leptons or hadrons, to NLO accuracy in QCD, in such a way that matching with a full shower program is possible. In case of decays into hadrons, NLO corrections to the decay processes are not included. This is unlikely to be necessary: most shower Monte Carlo do already a good job in dressing the W decay with QCD radiation, since they have been fit to LEP2 data.

This generator is based upon the calculation of refs. [2], [3], [4]. The effect of off-shell singly resonant graphs is fully included in the calculation. Anomalous coupling can also be included.

If the W-bosons decay into a leptons of the same flavour (e.g. $e^+ e^-$), then the ZZ production of this signal should be considered separately using the POWHEG-BOX-ZZ program. Interference between these two process is negligible (see [1]) and is not included. 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/WW
$ make pwhg_main
```

Then do (for example)

```
$ cd test
$ ../pwhg_main
```

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

```
$ cd POWHEG-BOX/WW
$ make main-PYTHIA-lhef
$ cd test
$ ../main-PYTHIA-lhef
```

3 Input parameters

Parameters in `powheg.input` that are specific to WW pair production:

```
vdecaymodeWp -11    !  decay mode of W+ (-1=dbar, -3=sbar, -7=dbar or sbar,
                    !                     -11=e+, -13=mu+, -15=tau+.)
vdecaymodeWm 13     !  decay mode  of W- (1=d, 3=s, 7=d or s,
                    !                      11=e-,13=mu-,15=tau-.)
dronly       0      !  (default 0), if 1 include only double
                    !  resonant contributions
zerowidth    0      !  (default 0), if 1 use on-shell W-bosons only
runningwidth 0      !  (default 0), if 1 use running width
fixedscale   -1     !  (default -1) if >= 0, use fixed scale mu = M_W
btlscalereal 0      !  (default 0) if 1, changes scale for real emission
btlscalect   0      !  (default 0) if 1, sets scale in counterterm
                    !   same as Born scale
withdamp     1      !  (default 1) use Born-zero damping factor
```

The CKM matrix is assumed diagonal. As an example

```
vdecaymodeWp -7      !  decay mode of W+ (-1=dbar, -3=sbar, -7=dbar or sbar,
                     !                    -11=e+, -13=mu+, -15=tau+.)
vdecaymodeWm 13      !  decay mode  of W- (1=d, 3=s, 7=d or s,
                     !                     11=e-,13=mu-,15=tau-.)
```

is the semileptonic decay $\mu\,\bar{\nu}_{\mu} +$ hadrons.

If `zerowidth` is absent or equal to zero, the W-boson's are given finite width. Singly resonant graphs are also included by default, unless the `dronly` flag is set to 1. If zerowidth is set to true, dronly is set to true regardless of what is in the powheg.input file. Dynamic widths can be used by setting the `runningwidth` flag to 1. As a consequence of the unitarity property of the CKM matrix, using PDG values for this matrix gives the same result as setting it to a diagonal matrix. For convenience, a diagonal CKM matrix is used. Seven anomalous couplings are used: `delg1_z`, `delg1_g`, `lambda_z`, `lambda_g`, `delk_g`, `delk_z`, `tevscale` (see section 3.2 of [1] and references therein for a definition of these). These are set to 0 by default, unless a non zero value is given in the `powheg.input` file. Note that in POWHEG, these couplings are independent of one another. If there are any relations (e.g. due to symmetry considerations) between couplings, these should be calculated independently and the input set accordingly.

If the flag `fixedscale` is set greater than or equal to 0, then the factorization and renormalization scales are fixed at M_W . Otherwise, a dynamic scale of the mass of the W-boson pair will be used. If the flag `btlscalereal` is set to 1, then the real contribution will be calculated using the transverse momentum of the hardest jet as a scale.

It is also necessary to employ a Born-zero damping factor, to prevent enhancement of the NLO due to small Born terms. For this reason, the flag `withdamp` should be set to 1. For further details, see appendix B of Ref. [1].

Bibliography

[1] T. Melia, P. Nason, R. Rontsch, and G. Zanderighi.

[2] L. J. Dixon, Z. Kunszt, and A. Signer, *Helicity amplitudes for O(alpha-s) production of W^+W^-, $W^\pm Z$, ZZ, $W^\pm\gamma$, or $Z\gamma$ pairs at hadron colliders*, *Nucl.Phys.* **B531** (1998) 3–23, [`hep-ph/9803250`].

[3] J. M. Campbell and R. Ellis, *An Update on vector boson pair production at hadron colliders*, *Phys.Rev.* **D60** (1999) 113006, [`hep-ph/9905386`].

[4] J. M. Campbell, R. Ellis, and C. Williams, *Vector boson pair production at the LHC*, `arXiv:1105.0020`. * Temporary entry *.