The POWHEG-BOX-V2/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 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 W hadronic decays have been fit to LEP2 data.

This generator is based upon the calculations of refs. [2], [3], [4]. The effect of off-shell singly resonant graphs is fully included. The CKM matrix is by default the Cabibbo matrix. Anomalous coupling can also be included.

If the W-bosons decay into leptons of the same flavour (e.g. $e^+\,e^-\nu_e\bar{\nu}_e$), then the ZZ production of this signal should be considered separately using the POWHEG-BOX-V2/ZZ program. Interference between these two processes 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 `POWHEG-BOX-V2/Docs` directory. The `V2` version of the WW process has been built by extending the `V1` version, allowing for the possibility of all decays, that can now be generated in a single run.

2 Generation of events

In the WW directory do
```
$ 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`:
```
$ make main-PYTHIA-lhef
$ cd test
$ ../main-PYTHIA-lhef
```

3 Input parameters

Parameters in `powheg.input` that are specific to WW pair production: `!`
```
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   0      !  (default 0) if 1 use fixed scale mu = M_W
```
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. Seven anomalous couplings are used: `delg1_z`, `de1g1_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 equal to 1, 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.

Several decay modes can be selected by an approriate flag in the `powheg.input` file:

```
semileptonic 1 !  one W goes to hadrons, one goes to leptons
e+e- 1         !  only electrons
mu+mu- 1       !  only muons
tau+tau- 1     !  only taus
leptonic 1     !  both W's go into leptons
hadronic 1     !  both W's go into hadrons
```

More conditions can be easily added, by editing the `alloweddec` function in the `init_processes.f` file. Notice that conditions must all be fulfilled. If no conditions are specified, you get all possible decays.

Bibliography

[1] T. Melia, P. Nason, R. Rontsch, and G. Zanderighi, *W+W-, WZ and ZZ production in the POWHEG BOX*, *JHEP* **1111** (2011) 078, [1107.5051].

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

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

[4] J. M. Campbell, R. K. Ellis, and C. Williams, *Vector boson pair production at the LHC*, *JHEP* **1107** (2011) 018, [1105.0020].