The POWHEG-BOX-V2/WWJ manual

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1 Introduction

The POWHEG-BOX WWJ program [1] can be used to generate the QCD production of W^+W^- + 1 jets 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 already do a good job in dressing the W decay with QCD radiation, since W hadronic decays have been fit to LEP2 data. The effect of off-shell singly resonant graphs is fully included. The CKM matrix is by default the Cabibbo matrix. The calculation is performed in the four-flavour scheme. Therefore it's mandatory to use a four-flavour PDF, as reminded in the template input cards.

If the W-bosons decay into leptons of the same flavour (e.g. $e^+e^-\nu_e\bar{\nu}_e$), then the ZZJ production of this signal should be considered separately. Interference between these two processes is negligible (see ref. [2], where the same interference is considered without the extra jet) 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.

When the MINLO option is switched on, the WWJ generator becomes NLO accurate also for inclusive W^+W^- production.

2 Generation of events

In the WWJ directory do

```
$ make pwhg_main
```

Then do (for example)

```
$ cd testrun-lhc
$ ../pwhg_main
```

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

```
$ make main-PYTHIA-lhef
$ cd test
$ ../main-PYTHIA-lhef
```

However, because the program is numerically intensive, we do not recommend to run it without the `POWHEG` parallel-feature version switched on, as described in detail in ref. [3]. A template input card can be found in the `testrun-wwj-parallel` directory. In the `testrun-minlo-parallel` directory, instead, we provide a template input card to perform a run with the MINLO option activated.

3 Input parameters

Parameters in `powheg.input` that are specific to WW pair production in association with one jet:

```
runningscale 0   !  (default 0), 0 = fixed scale
minlo 0          !  (default 0) if 1 turn on the MINLO option
```

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

```
e+e- 1                !    only electrons
mu+mu- 1              !    only muons
tau+tau- 1            !    only taus
leptonic_notau 1      !    both W's go into leptons (but not τ)
leptonic 1            !    both W's go into leptons
hadronic 1            !    both W's go into hadrons
semileptonic 1        !    one W goes into hadrons, one into leptons
semileptonic_notau 1  !    one W goes into hadrons, one into leptons (but not τ)
e+mu- 1               !    W+ decays to electrons, W- to muons
mu+e- 1               !    W- decays to electrons, W+ to muons
```

More conditions can be easily added, by editing the `alloweddec` function in the `init_processes.f` file. If no condition is specified in the input card, the default decay channel is assumed, namely `e+mu-`.

In the case of leptonic final states, we release a template analysis `pwhg_analysis-WW-template.f` with a set of differential distributions.

As a final remark, we note that in ref. [1] we found that closed fermion loops slow down the calculation considerably, yet provide no sizable effect in any

distribution that we considered (within our numerical accuracy). Hence, we also provide the possibility to run the code without including closed fermion loops. This can be achieved by setting the variable `GOSAMDIR` to `GoSamlib_nofboxes` in the Makefile, and recompiling the code from scratch.

References

[1] K. Hamilton, T. Melia, P. F. Monni, E. Re and G. Zanderighi, arXiv:1606.07062 [hep-ph].

[2] T. Melia, P. Nason, R. Rontsch and G. Zanderighi, JHEP **1111** (2011) 078 doi:10.1007/JHEP11(2011)078 [arXiv:1107.5051 [hep-ph]].

[3] POWHEG-BOX-V2/Docs/V2-paper.pdf