Status of the POWHEG BOX

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MCWG, Cern 11/12/2016

Outline

- What is now available in V2
- Treatment of resonances
- Extensions of the MiNLO method

What is available in V2

- Parallel run feature: runs can be split into parallel jobs, also at the level of grid generation. V2 processes are normally provided with a shell script to run them in parallel on multi-core computers. The script can be easily adapted for parallel runs distributed among different nodes of a batch machine.
- Reweighting feature: it is available, it uses the format of the Les Houches agreement. It can be used to reweight for any parameter of the cross section that does not affect phase space kinematics and hardest radiation generation. It is also used, for example in processes with very complex NLO virtual contributions. Events are generated without virtuals, and virtual effects are added by reweighting.

Stages are as follows:

- Parallel Stage 1: importance sampling grids for the calculation of the $\tilde{B}$, and remnants contributions are set up. It is sometimes convenient to iterate this stage (i.e. compute new grids starting from the previous ones) two or three times.
- Parallel Stage 2: the NLO cross section is computed, and upper bounding envelopes of the $\tilde{B}$, and remnants contributions are set up, to be used for the unweighted generation of underlying Born and remnant configurations.
- Paralle Stage 3: set up upper bounding envelopes for the generation of the hardest radiation from given underlying Born events.
- Parallel Stage 4: Les Houches events are generated.

Each stage should be started when the files generated in the previous stages are available. Each stage loads all previous files that it can find, i.e. if some previous stages are not completed, it will use a lower statistics previous stage.

To do:

- If the number of stages is large, failure of some runs in each stage become more and more likely. The program should be able to detect common symptoms of failure, and to refuse the files from failed runs. An experimental feature of this sort is available for stage 3 (to refuse failsed stage 2 runs), but it is missing for the other stages.
- An automatic program to inspect the results of the final event generation should be set up, typical in order to detect eccessive upper bound failures in the generation of events.

Reweighting

Instruction in
`POWHEG-BOX-V2/Docs/README.LesHouchesReweighting}`. In essence, runs are performed with the following lines in the `powheg.input` file:

```
lhrwgt_id 'xxx'
lhrwgt_descr 'some info'
lhrwgt_group_name 'some name'
lhrwgt_group_combine 'foo'
```

in the generation of the initial .lhe events. Re-running the program with the lines

```
compute_rwgt 1
lhrwgt_id 'yyy'
lhrwgt_descr 'some info'
lhrwgt_group_name 'some name'
lhrwgt_group_combine 'foo'
```

will generate a new `.lhe` file reweighted according to the new settings of the `powheg.input` file.

Resonance treatment

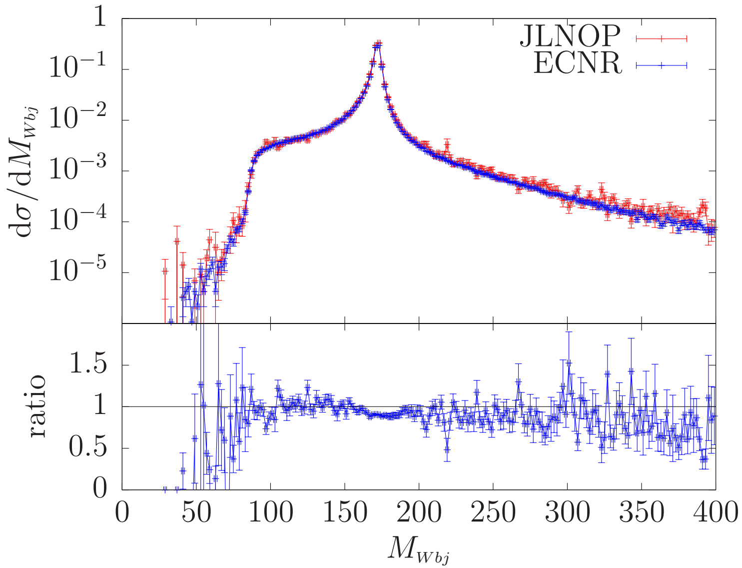
- A generator for $t\bar{t}$ including radiation in resonance decay, (NLO corrections using the Narrow Width Approximation) has appeared in Campbell,Ellis,Re,P.N, 2014.
- A method to build a POWHEG generators including radiation in resonance decays has appeared (Jezo,P.N.,Sept.2015), and has been applied to single top production.
- The method of Jezo,P.N. is now being applied to $t\bar{t}$ production in the 4-flavour scheme (i.e. with massive b quarks). Jezo,Lindert,Oleari,Pozzorini,P.N.
- Previous generators for Drell-Yan processes including NLO Electro-Weak corrections (Barz etal., 2012 and 2013) had electromagnetic radiation from resonance decay. They are now being ported to the new, resonance aware code, and tested for differences.

Resonance aware algorithm in two words: it adopts different kinematics, preserving the mass of the resonances in the generation of radiation, as the final state gets close to a resonant configuration.
Resonance aware code considerably different from `V2`.

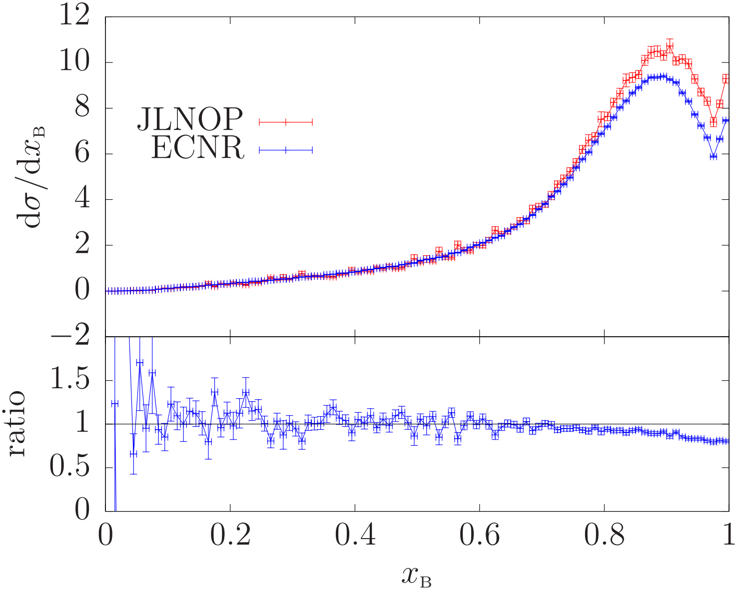
- Automatic phase space generation for underlying Born kinematics. This was needed because a different phase space implementation with appropriate importance sampling is required for each resonance structure contributing to a given process.
- "Regular" contributions, i.e. contributions that do not have any singular regions because of their particular resonance structure, now arise commonly. They should be treated with appropriate importance sampling. The whole system of integration and generation of configurations has been rewritten, in order to handle all cases in a uniform way.

- It is at times better to generate multiple radiation in a single Les Houches event, one for production and one for each resonance that can radiate. This feature was achieved by brute force in the `ttb_NLO_dec` generator (the one using the narrow width approximation), and is now properly implemented in the resonance aware version.
- Because of the previous item, the interface to the shower generator becomes now more complex. No standard is defined at the moment for vetoing resonance radiation. In practice, we end up examining the event after shower, and discarding it if its radiation violates our vetos.

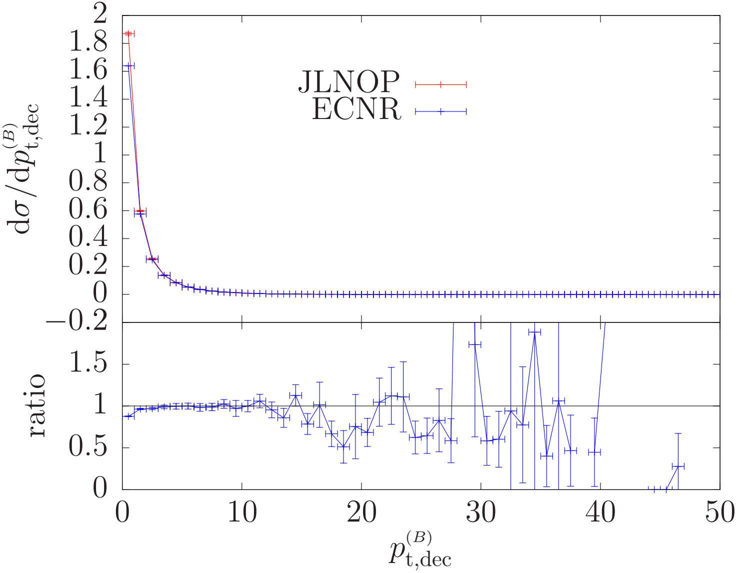
Comparison of Jezo etal with Ellis etal results



Comparison of Jezo etal with Ellis etal results



Comparison of Jezo etal with Ellis etal results



- Difference in normalization due to different treatment (multiplicative vs. additive) of NLO corrections to decay.
- Compare well for "reconstructed" top mass from W and b-jet.
- Differences observed in the B fragmentation function in the "top" rest frame
- Difference seem to be due to gluons with energy $< 1\,\mathrm{GeV}$. This is the region when the emission from decay and production cannot be clearly separated. This may be due to interference effects, or to the different separation if soft effects ($E < \Gamma_t$) in the two codes, with consequent difference in the hadronization of the b quark.

These and several other questions of interest regarding the theoretical accuracy of $t\bar{t}$ generators can be addressed with these tools.

MiNLO

Generic implementation of MiNLO available since Hamilton,Zanderighi,P.N. 2012. It is straightforward to use it to generate "traditionally" merged samples of processes with associated jets (No one is doing this at the moment).
MiNLO', "Merging without merging" and NNLO PS generators, Hamilton,Oleari,Zanderighi,P.N. 2012. Several applications:

- HJ Hamilton,Re,Zanderighi,P.N. 2013, quark mass effects Hamilton,Zanderighi,P.N. 2015.
- Drell Yan Karlberg,Re,Zanderighi, 2014
- HW, HZ Luisoni,Oleari,Tramontano,PN, 2013

MiNLO' can be applied to heavy neutral systems production in association with up to 1 jet at the Born level. One main goal of this method is to extend it to more associated jets.

MiNLO' extensions to higher multiplicity

Very recent progress has come from Frederix,Hamilton, December 2015 propose an extension of the MiNLO' method to add more associated jets, and discuss the case of Higgs production with up to 2 jets. The paper is complex (as expected ...), exciting, and we are studying it carefully.

Plans

- After completion of the $t\bar{t}$ implementation, resonance aware code should become a V2 replacement.
- MiNLO extensions: FH work should be carefully evaluated.