MC@NLO tutorial

The automatic version of MC@NLO (aMC@NLO) which uses MadGraph, MadLoop and MadFKS is not yet publicly available. So, instead of using the MadGraph code, this tutorial will be on the original (non-automatic) MC@NLO package by Stefano Frixione and Bryan Webber (and Fabian Stoeckli, Paolo Torrielli and Chris White). The official website of the the MC@NLO code is http://www.hep.phy.cam.ac.uk/theory/webber/MCatNLO/. There you can find the code, the manual and references. The MC@NLO code generates events including the Monte Carlo subtraction terms (will be explained in detail tomorrow) accurate at NLO: these events can be showered using the Herwig or Herwig++ parton shower codes. The MC@NLO code is written in Fortran77.

For your convenience, we have provided a package that already includes the Herwig shower. It can be found in the folder /home/sluser/paolo/ on the virtual machine. Because of disk space, it has been preferred to remove the folders relative to Herwig++, which however will be equally included in the following description.

The MC@NLO package is structured as follows:

- There is a limited set of process implemented, see table 1 and table 2 of the manual.
- Each implemented process is a separate code that can be found in the `./srcCommon/` directory.
- In the `./srcHerwig6/` (and `./srcHerwigpp/`) directories codes specific to the (respective) parton showers can be found. In particular, here is where the Monte Carlo subtraction terms are computed; remember that they depend on the parton shower used.
- In the `./HW6Analyzer/` (and `./HWppAnalyzer/`) directories the analysis files should be written. In general the output from Herwig is too large to be saved on the hard disk. So, the only way to circumvent this is to do our analysis (i.e. to apply cuts and make histograms for observables) event-by-event while the parton shower is running. This means that one needs to write his/her analysis file before the parton shower is run. In these analysis directories there are already many examples of analysis files that can be used directly and/or adapted to your own analysis.
- The main script to launch a run is the `MCatNLO.inputs` bash script that can be found in the main directory. There are many parameters that can be changed or need to be defined. Please read it carefully and try to understand what the parameters mean. Some of the most important are
  - ECM, which is the collider energy.
  - PART1, PART2, the colliding hadrons.
  - PDFGROUP, PDFSET, the pdf distributions. For this tutorial, the only available choices are PDFGROUP=CTEQ, and PDFSET=10041, 10042, 10550, 19070.
  - IPROC, which defines the process. Should be a negative number corresponding to the numbers in the table 1 and 2 of the manual. If you don't want to include the underlying event, subtract another 10000 from the process number. So, if you want to do W^+-boson production with the W^+-boson decaying to a positron and a neutrino without the underlying event, you should set IPROC=-11461.
  - NEVENTS, this is the number of (unweighted) events that the code will generate.
  - MCMODE, should be set to HW6 to use the Herwig code
  - HWUTI, define here the analysis files that should be used on the events showered by the parton shower code (and also the file that deals with histogramming routines `mcatnlo_hbook`).
  - And the final line of the file. This should be equal to runMCatNLO if you want to generate events and run the Herwig shower. If you only want to compile the code (good for debugging) or only generate events this line should be changed. Also, if your events are already generated, and you only want to shower them, e.g. because you changed your analysis file, change this line to runMC.

To run the code, type

```
./MCatNLO.inputs
```

from the main directory. This should (in the following order) compile the code, integrate the cross section and generate the events, compile the parton shower, and shower the events. Depending on if you are working on a Linux or a Mac computer, the script will create a directory `./Linux/` or `./Darwin/` with the results, log files, etc., respectively. Note that NLO computations are a lot slower than LO, so the generation of events might take quite some time (easily more than 30 minutes).

What to do in this tutorial:

1. Familiarise yourself with the structure of the code. Pay particular attention to the `MCatNLO.inputs` file and the `HW6Analyzer/` directory.
2. Generate events for W-boson production including leptonic decay to a positron and a neutrino to be matched to the Herwig parton shower using the default analysis file, `mcatnlo_hwanllp`. This should be the default setting in the `MCatNLO.inputs`.
3. This will produce a file `.TOP`, which contains the the distributions that are booked in `mcatnlo_hwanllp` (feel free to book the histograms you want, not just the default ones!). There is an executable (called `td`) of the drawing programme TopDrawer in the directory `srcCommon`. This version of Top Drawer works fine on this VM provided one plays some tricks. First edit the `.TOP` file and write as first line `set device postscript orient=3`. Then replace all the "SET TITLE SIZE -1.2247" or "SET LABEL SIZE -1.2247" (or similar) in the `.TOP` by some positive numbers (like 1.0). Finally, execute `./td <filename>.TOP`, which creates `<filename>.TOP.ps` (you can view it with `ghostview`).
4. Compare the results from MadFKS (this morning) with the results from MC@NLO. Discuss the differences with your neighbours. In particular, look at the distribution for the transverse momentum of the W-boson and compare with the plot below.
5. Try the same for another process.