CTEQ school 2018 Tutorial session
Mayaguez
2018

Herwig Tutorial

Part I

Introduction to Herwig 7

In this first part of the tutorials you will get to know Herwig. The actual tutorial is part of the online Herwig documentation. The Herwig homepage is at `http://herwig.hepforge.org/`.

On the Herwig homepage you find a section *Tutorials*. In this tutorial you work through the section *Getting Started* which contains the subsections

- The first run
  - We have prepared for you starting input file: LHC-Matchbox.in. You can find in the herwig folder (see PartI sub-folder) on your VM.
  - Due to limited time of the session to get started we switch to LO matrix elements in LHC-Matchbox.in. (If you would like to play with NLO matching please contact me I have prepared a virtual farm for you! The virtual farm has more CPUs so you can make calculations faster and have full installation of Herwig 7.1! **Warning:** the farm is an experimental setup and all the tutorial can be done on your VM.)
- A look at input files.
- More runs, switching things on and off.
- Using different matrix elements and showers. Play with it but please stick to LO matrix element. Check how to switch showers.
- More on matrix elements. Due to VM size limitations we have not installed external matrix element providers. However, you can have a look and if you would like to try them use the virtual farm.

Part II

$t\bar{t}$ and non-perturbative effects

Based on what you have learned in the Section I you should be able now to:

1. Create an input file for LO $t\bar{t}$ production at $\sqrt{s} = 7$ TeV for both angular (default shower in H7) and dipole showers. Go and do it!
   Hints:

   - There are useful snippet files which you can use. See the example file from the part I or the online Herwig documentation.
   - Read carefully the section on dipole shower you need to use Five Flavours scheme. There is a snippet for it!
   - Set the scale (ScaleChoice) to TopPairMTScale (see for example `https://arxiv.org/pdf/1606.03350.pdf` for a discussion on the possible scale choices for this process).
   - Does the generator complains about something when you try to use the file? Maybe consider setting HardProcessWidth to 0 for both t and $\bar{t}$ in the Hard Process.
   - The analysis which we are going to use is implemented as MC_TTBAR Rivet plugin[1] is for semi-leptonic $t\bar{t}$ production (by the way please add the analysis to the input file!) . In order to set it please see a snippet in PartII folder.

2. Switch off MPI, and compare the results using rivet-mkhtml (the same script which you used for the Python Parton Shower tutorial).

3. Switch off Hadronization and generate events.

4. Switch off Colour reconnection model. Hint you could also set the probability of reconnection to 0. Do you know how to do it? Look at the online manual, you can also check default settings of Herwig in /opt/hep/share/Herwig/defaults. If you want to know more on Effects of color reconnection on tt final states at the LHC see `https://arxiv.org/abs/1407.6653`.

5. Switch off intrinsic momentum smearing in the dipole parton shower.

[1] You can see its sources code if you are interested (/opt/hep/rivet/MC_TTBAR.cc).

Part III

Additional variations

Most likely you won't have time to try it but of course in Herwig you can also do:

- Parton Shower scale variation see `https://arxiv.org/abs/1605.01338` and `https://arxiv.org/abs/1605.08256` as well as the online manual.
- NLO matching to the matrix element using two Showers and two matching schemes. You can see the plots at the Herwig webpage: `https://herwig.hepforge.org/plots/herwig7.0/Rivet-LHC-Jets/MC_TTBAR/index.html`.

That's it!

Thanks for trying Herwig! Please ask as much as you can here, but if you have any questions later on, please email us at `herwig@projects.hepforge.org` or have a look at our online documentation, where many how-tos can be found, and we'll add more on request. For detailed documentation refer to our manual, `arxiv:0803.0883`, and the MCnet review paper, `arxiv:1101.2599`.