Table of Contents

HEP MC and Data Analysis Tutorial 2017

Tutorial per il corso di Fisica Nucleare e Subnucleare, Dipartimento di Fisica, Università degli Studi di Trieste.

References

- homepage: http://madgraph.hep.uiuc.edu/
- download page: https://launchpad.net/mg5amcnlo

Delphes

- homepage: https://cp3.irmp.ucl.ac.be/projects/delphes
- list of branches: https://cp3.irmp.ucl.ac.be/projects/delphes/wiki/WorkBook/RootTreeDescription
- to install it from MG5 shell: `install Delphes`

ROOT

- homepage: http://root.cern.ch/drupal/
- reference guide: http://root.cern.ch/root/html/
- to set it up on your ts-dip-phys pc: `source setup.sh`

To start

Preliminary steps:

1. create a folder `HiggsTutorial`, which will be our "working directory"
2. download the this version of MadGraph5: `MG5_aMC_v2.5.5` from this site: https://launchpad.net/mg5amcnlo/2.0/2.5.x/+download/MG5_aMC_v2.5.5.tar.gz
3. move the downloaded file (`MG5_aMC_v2.5.5.tar.gz`) to our working directory and extract it (a new sub-directory `MG5_aMC_v2_5_5` should have been created, which we will call "MG5 directory")
4. copy the script `setup.sh` (attached here: setup.sh) inside the working directory
5. from a terminal, from inside the working directory, execute the command `source setup.sh`: this will setup ROOT, gcc and python, and has to be done each time we open a new termnal (!)
6. test MadGraph: from inside the MG5 directory, from the terminal execute: `./bin/mg5_aMC`; if it works you should be inside the MG5 shell
7. try to generate a physics process: from inside the MG5 shell, give the command `generate p p > t t~` (this should prepare the generation of pp -> ttbar events)
8. exit MG5 shell, with CTRL+D

MadGraph preparation:

1. eventually modify the MG5 settings for the used browser and text editor: modify the text file `input/mg_configuration.txt` accordingly (suggested gedit or nano as text editor, firefox as browser)
2. enter the MG5 shell: from the MG5 directory, from a terminal (after the setup!) type `./bin/mg5_aMC`
3. type `install pythia-pgs` to install Pythia6 (parton shower and hadronisation software)
4. type `install Delphes` to install the latest version of Delphes (detector simulation and object reconstruction fast simulation software)

Generate Processes with

Let's start with the MG5 tutorial:

1. from the MG5 shell, type `tutorial`
2. follow the instructions on the screen

Then let's have one more exercise. What's the cross-section (at LO) for the process pp -> ttbar, with a CME of 7 TeV and a top mass of 172.5 GeV?

1. if you already have a ttbar directory, you can directly move to point 5
2. from the MG5 shell, type `generate p p > t t~`
3. then create the output directory, still from the MG5 shell, typing `output ttbar`
4. exit MG5 (CTRL+D)
5. enter the `ttbar` directory
6. enter the `MadEvent` shell: `./bin/generate_events`
7. press enter
8. now we are asked to modify the cards: we want to change both the CME and the top mass, so we have to modify both `run_card.dat` and `param_card.dat`
9. to modify `run_card.dat` type 2, then ENTER
10. find the lines with the energies of the two beams and set them to 3500 GeV each
11. when finished, save the file and exit
12. now you can modify `param_card.dat` typing 1, then ENTER
13. find the line like `6 1.730000e+02 # MT`, and set 1.725000e+2 instead of 1.730000e+02
14. when finished, save the file and exit
15. then press ENTER and the computation will start
16. wait few minutes you should get the result: you can read it from the screen or from the file `ttbar/crossx.html`

Process outputs: Pythia and Delphes

We already installed Pythia and Delphes. Now we can turn them on when generating events, in order to also simulate the parton shower and the hadronisation, as well as the detector simulation:

1. if you already have a ttbar directory, you can directly move to point 5
2. from the MG5 shell, generate the usual test process `generate p p > t t~`
3. create an output directory: output `output ttbar`
4. exit MG5 (CTRL+D)
5. enter the ttbar directory: `cd ttbar`
6. enter `MadEvent` shell: `./bin/generate_events`
7. switch Pythia to ON
8. switch Delphes to ON (NB: you might need to do it twice, until you see "Delphes" written there)
9. type 0, ENTER, and then again 0, ENTER
10. the events will be generated with Pythia and Delphes switched ON
11. we can give a look at the text file called `tag_1_pythia.log` inside the directory `ttbar/Events/run_01/`: this log contains, among other info, the full record of the fort 10 generated events (you can see the initial protons, the inital partons, the intermediate tops and their decay products, as well as all the products of the subsequent parton shower and hadronisation - quite a long list...)
12. the delphes output file is also stored in the `ttbar/Events/run_01/` directory, with a .root extension

To read Delphes outputsç

1. dowload the file `MyReader.C` from here: MyReader.C, and put it inside the directory `Delphes/examples` (note: it's inside MG5 directory)
2. open the file with a text editor
3. uncomment the proper lines in order to create, fill and show a histogram, then save the file
4. run the macro on the latest MG5 run output: from a terminal (again after the usual setup!), go to the directory `Delphes` and type `root -l 'examples/MyReader.C("../ttbar/Events/run_XX/tag_1_delphes_events.root")'`

Main exercise: Higgs to 4 leptons

Goal:

- select events coming from h->ZZ->4 lep and to produce a histogram with the reconstructed Higgs mass in these events
- compare "data" with MC simulation for Higgs signal and ZZ background
- everything should be done at CME = 8 TeV, considering the data integrated luminosity of 25 fb^{-1}

Where to get the data:

- find the Delphes output here: data_events.root

Generate the signal:

- as usual, `./bin/mg5_aMC`
- IMPORTANT: before the `generate` command, type `import model heft`
- `generate p p > h > l+ l- l+ l-`
- `output h4lep`
- exit MG5, enter h4lep directory, enter MadEvent: `./bin/generate_events`
- set Pythia ON, Delphes ON, the rest OFF
- when prompted, modify the run card:
    - ♦ set the CME to 8 TeV (4000 GeV each beam)
    - ♦ check that `False  = cut_decays` (should be by default in latest MG5)
- (eventually change the Higgs mass in the param card)
- IMPORTANT: later we will multiply the signal x-sec given by MG5 by 10 (at LO both the x-sec and the BR are underestimated)

Generate the background (ZZ->4lep):

- as usual, `./bin/mg5_aMC`
- `generate p p > l+ l- l+ l- /h` (the `/h` excludes the Higgs as intermediate state)
- `output zz4lep`
- exit MG5, enter zz4lep directory, enter MadEvent: `./bin/generate_events`
- set Pythia ON, Delphes ON, the rest OFF
- when prompted, modify the run card:
    - ♦ set the CME to 8 TeV (4000 GeV each beam)
    - ♦ check that `False  = cut_decays` (should be by default in latest MG5)

How to produce the final plot:

- look at the code `MyHiggs4l.C`: MyHiggs4l.C
    - ♦ use it as a template for your macro to create a histogram out of each delphes output files (signal, background, data)

- the two inputs to the macro are the name of the root file with the delphes output and the output file where to store the histogram
- example:
  - `root -l -b -q 'examples/MyHiggs4l.C("../h4lep/Events/run_01/tag_1_delphes_events.root","sig`
  - `root -l -b -q 'examples/MyHiggs4l.C("../zz4lep/Events/run_01/tag_1_delphes_events.root","ba`
  - `root -l -b -q 'examples/MyHiggs4l.C("data_events.root","data.root")'`

- then look at the code `MyHistMerger.C`: MyHistMerger.C
  - use it as a template for your code to read the three inputs and merge them in a final plot
  - note the signal x-sec multiplied by 10

-- MichelePinamonti - 2017-12-13

- setup.sh: setup.sh
- MyReader.C: MyReader.C
- data_events.root: data_events.root
- MyHiggs4l.C: MyHiggs4l.C
- MyHistMerger.C: MyHistMerger.C

This topic: Main > UnitsHiggsTutorial2017
Topic revision: r3 - 2017-12-14 - MichelePinamonti