MadGraph Tutorial - Basics

From Theory to Events

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Getting the code

Download the code

```
$ wget https://github.com/mg5amcnlo/mg5amcnlo/archive/refs/tags/v3.7.1.tar.gz
$ tar xzf v3.7.1.tar.gz
$ cd mg5amcnlo-3.7.1
$ ./bin/mg5_aMC
```

Outline of the Tutorial

I. Built-in MG5 tutorial

II. Understanding the cards

III. Understanding the syntax

IV. Top quark - Mass scan

V. Unitarity in gauge theories

Where to find help?

- Ask us
- Use the command “help” / “help XXX”
  - ➡ “help” tells you the next command that you can do
- Launchpad:
  - ➡ https://answers.launchpad.net/madgraph5
  - ➡ FAQ: https://answers.launchpad.net/madgraph5/+faqs

Exercise I — Built-in Tutorial

- Launch the code

  → `$./bin/mg5_aMC`

- Type “tutorial”

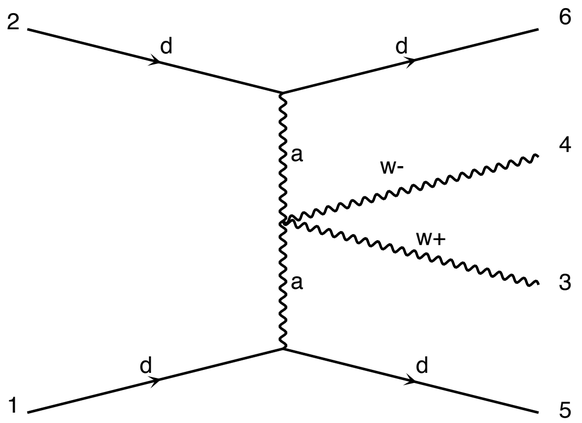
  → Follow instructions!

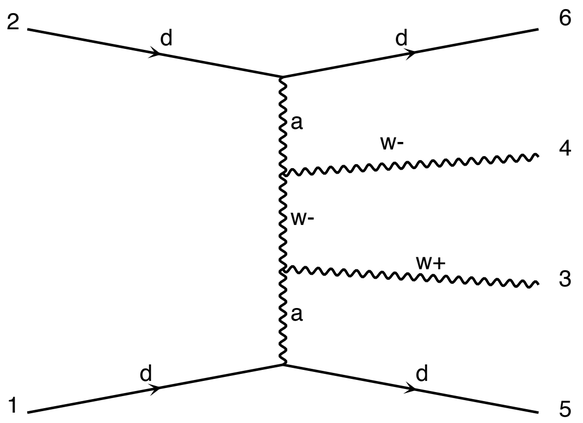
Exercise II — Parameters and Cards

- Compute the LO cross-section for our BSM background (see later)
  - ➡ generate p p > mu+ mu-
- Check
  - ➡ What is the Z mass?
  - ➡ Are there any cuts? (Do we need cuts?)
  - ➡ Beam energy
- Useful cards to check are
  - ➡ **param_card:** model parameters
  - ➡ **run_card:** beam/run parameters and cuts

Exercise III — Syntax

- What's the meaning of the order QED/QCD
- What's the difference between
  - ➡ p p > t t~
  - ➡ p p > t t~ QED=2
  - ➡ p p > t t~ QED=0
  - ➡ p p > t t~ QCD=0
  - ➡ p p > t t~ QED<=2
  - ➡ p p > t t~ QCD^2==2
- Compute the cross-section for each of those and check the diagram
- Generate VBF process
- check that you have the diagram that you want





Exercise III — Syntax

- Generate the cross-section **and the distribution** (invariant mass) for
  - ➡ p p > mu+ mu-
  - ➡ p p > z, z > mu+ mu-
  - ➡ p p > mu+ mu- $ z (warning set sde_strategy=1 in the run_card)
  - ➡ p p > mu+ mu- / z

Hint: To plot automatically distributions

mg5> install MadAnalysis5

Exercise IV — Mass Scan

- Compute the cross-section for
  - ➡ p p > t t~, t > w+ b, t~ > w- b~
    - **For top mass 170,172,…,182 GeV**
    - **Trick you can use:** *set mt scan:range(170,182,2)*
    - Does the cross section decrease/increase (why should it)?

Exercise V — Unitarity in gauge theories

Consider the process e+ e- > w+ w-

- Which diagrams contribute?
  - Generate
    1. the full process,
    2. the process with no ZWW vertex
    3. With only the neutrino diagram
  - Use the **"/"** syntax in the *generate* command to veto specific particles (see also *help generate*)
- Calculate the cross section at $\sqrt{s} = 165,175,\ldots,205,400$ GeV (script it!) and check the behavior

  Hint: *set beam 200* sets both beams to energy of 200