Monte Carlo generators Tutorial

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Installation

✦ Installation on the local machines

- ✤ Installation of PYTHIA 8 within MG5_aMC
- ✤ Installation of MADANALYSIS 5 (including FASTJET, DELPHES and the PAD)

```
cd
cat >> .bashrc << EOF
. /opt/root/root/bin/thisroot.sh
export PATH=\$PATH:/opt/lhapdf/bin
export LD_LIBRARY_PATH=\$LD_LIBRARY_PATH:/opt/lhapdf/lib
export PYTHONPATH=\$PYTHONPATH:/opt/lhapdf/lib64/python2.7/site-packages
EOF
```

Environment

```
mkdir madgraph
cd madgraph
tar zxf /opt/software/MG5_aMC_v2.6.2.tar.gz
./MG5_aMC_v2_6_2/bin/mg5_aMC
install pythia8 --source=ucl
exit
```

MG5_AMC and PYTHIA 8

```
cd
mkdir madanalysis
cd madanalysis
tar zxf /opt/software/ma5_v1.6.41.tgz
mv madanalysis5/madanalysis/install/install_service.py madanalysis5/madanalysis/install/install_service.py.orig
mv madanalysis5/madanalysis/install/install_pad.py madanalysis5/madanalysis/install/install_pad.py.orig
cp -p/opt/software/install_service.py madanalysis5/madanalysis/install/
cp -p/opt/software/install_pad.py madanalysis5/madanalysis/install/
./madanalysis5/bin/ma5
install delphes
install PAD
install fastjet
quit
```

MA5, FASTJET, DELPHES and the PAD

Getting started with MadGraph5_aMC@NLO

✦ A first tutorial

✤ Get used to the MG5_aMC syntax

★ Start MadGraph5_aMC@NLO (*bin/mg5_amc*) and type *tutorial*

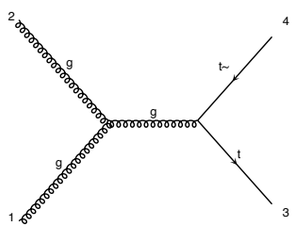
✦ Content of the tutorial

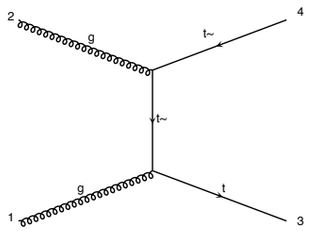
✤ Generating top-antitop events at the parton level (*generate p p > t t~*)

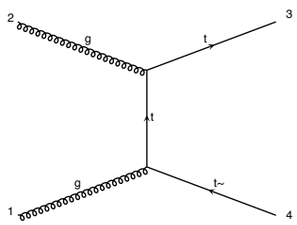
✤ Generating the code for the matrix element (after *output MY_FIRST_MG5_RUN*)

★ Check the FORTRAN version of the matrix element:

MY_FIRST_MG5_RUN/SubProcesses/P1_gg_ttx/matrix1.f








```
C       ----------
C       BEGIN CODE
C       ----------
        CALL VXXXXX(P(0,1),ZERO,NHEL(1),-1*IC(1),W(1,1))
        CALL VXXXXX(P(0,2),ZERO,NHEL(2),-1*IC(2),W(1,2))
        CALL OXXXXX(P(0,3),MDL_MT,NHEL(3),+1*IC(3),W(1,3))
        CALL IXXXXX(P(0,4),MDL_MT,NHEL(4),-1*IC(4),W(1,4))
        CALL VVV1P0_1(W(1,1),W(1,2),GC_10,ZERO,ZERO,W(1,5))
C       Amplitude(s) for diagram number 1
        CALL FFV1_0(W(1,4),W(1,3),W(1,5),GC_11,AMP(1))
        CALL FFV1_1(W(1,3),W(1,1),GC_11,MDL_MT,MDL_WT,W(1,5))
C       Amplitude(s) for diagram number 2
        CALL FFV1_0(W(1,4),W(1,5),W(1,2),GC_11,AMP(2))
        CALL FFV1_2(W(1,4),W(1,1),GC_11,MDL_MT,MDL_WT,W(1,5))
C       Amplitude(s) for diagram number 3
        CALL FFV1_0(W(1,5),W(1,3),W(1,2),GC_11,AMP(3))
C       JAMPs contributing to orders ALL_ORDERS=1
        JAMP(1,1)=+IMAG1*AMP(1)-AMP(2)
        JAMP(2,1)=-IMAG1*AMP(1)-AMP(3)
```

Generating events

✦ Generating events: *launch*

✤ Switch on PYTHIA 8, MADSPIN and switch off MADANALYSIS 5

```
/================ Description ================|================ values ================|======= other options =======\
| 1. Choose the shower/hadronization program   |      shower = Pythia8                  |    OFF                    |
| 2. Choose the detector simulation program    |    detector = Not Avail.               |    Please install module  |
| 3. Choose an analysis package (plot/convert) |    analysis = OFF                      |    MadAnalysis5           |
| 4. Decay onshell particles                   |     madspin = ON                       |    onshell|OFF             |
| 5. Add weights to events for new hypp.       |    reweight = OFF                      |    ON                     |
\=============================================================================================================/
```

✦ Investigate the content of the various cards

✤ Understand what they are and what they control

```
/-----------------------------------------------------\
|  1. param   : param_card.dat                        |
|  2. run     : run_card.dat                          |
|  3. pythia8 : pythia8_card.dat                      |
|  4. madspin : madspin_card.dat                      |
\-----------------------------------------------------/
```

✤ Start the run. The web output is:

Run	Collider	Banner	Cross section (pb)	Events	Data	Output	Action
run_01	p p 6500.0 x 6500.0 GeV	tag_1	504.3 ± 4.1 ± systematics	10000	parton madevent	LHE	remove run launch detector simulation
run_01_decayed_1	p p 6500.0 x 6500.0 GeV	tag_1	504.3 ± 4.1	10000	parton madevent	LHE	remove run launch detector simulation
					pythia8	LOG HEPMC	remove run launch detector simulation

✦ Continue the tutorial

Event generation

✦ Go to the folder *MY_FIRST_MG5_RUN/Events/run_01*

- ✤ The hard scattering events are in the file *unweighted_events.lhe.gz*
- ✤ The showered events are in the file *tag_1_pythia8_events.hepmc.gz*

✦ Generate 4 samples of 10000 events (both hard and showered events)

- ✤ top-antitop (*p p > t t~*)
- ✤ Drell Yan (*p p > l+ l-*)
- ✤ W + jets (*p p > l+ vl* or *l- vl~*)
- ✤ single top in the tW mode (*p p > t W-* and *t~ W+*)

Event analysis

✦ We will analyze those events with MADANALYSIS 5

✤ Go to http://madanalysis.irmp.ucl.ac.be/wiki/tutorials

Collection of tutorials on the normal mode

Chapter 1: What is `MadAnalysis`? ⇨https://madanalysis.irmp.ucl.ac.be/raw-attachment/wiki/tutorials/NormalMode-Tuto1.pdf

Chapter 2: Installation & startup ⇨https://madanalysis.irmp.ucl.ac.be/raw-attachment/wiki/tutorials/NormalMode-Tuto2.pdf

Chapter 3: A first analysis with `MadAnalysis` 5 ⇨https://madanalysis.irmp.ucl.ac.be/raw-attachment/wiki/tutorials/NormalMode-Tuto3.pdf

Chapter 4: Using `FastJet` ⇨https://madanalysis.irmp.ucl.ac.be/raw-attachment/wiki/tutorials/NormalMode-Tuto4.pdf

✤ Four tutorials to be applied on the above event files

★ Chapter 1: basic information about MADANALYSIS 5

★ Chapter 2: Installation ➢ go directly to page 16–22 (ignore the rest)

★ Chapter 3: Analysis of all unweighted event files (single top is our signal)

➢ Hard-scattering level only

➢ Use the cross sections returned by MG5_aMC

➢ Investigate which observables could help to observe the signal

➢ Which significance do you get?

★ Chapter 4: Reconstruction of the *hepmc* event files (part 1 only)

Analysis of the reconstructed events

✦ We will analyze the events with MADANANALYSIS 5

✤ Analyze the reconstructed event files as done in the third tutorial

➢ Check different observables

➢ Try to observe the single top signal

➢ Which significance do you get?

✦ Make use of the MADANALYSIS5 - DELPHES interface (detector simulation)

✤ Start MADANALYSIS 5 in the reco mode (*bin/ma5 - R*)

```
[ma5>set main.fastsim.package = delphes
[ma5>set main.fastsim.detector = cms-ma5tune
[ma5>import samples/TT.hepmc.gz
MA5:    -> Storing the file 'TT.hepmc.gz' in the dataset 'defaultset'.
ma5>submit
```

✤ Analyze the reconstructed ROOT files

➢ Check different observables

➢ Try to observe the single top signal

➢ Which significance do you get?

➢ Compare with the no-detector simulation case

Bonus - an MSSM signal

- Generate events describing electroweakino pair-production
  - Import the MSSM model
  - Type: *define x1 = x1+ x1-; generate p p > x1 n2; output; launch*
  - Go directly to the DELPHES level with MADANALYSIS 5 and analyze those events
  - The SUSY signal is now the signal sample, the SM ones the backgrounds
- Design an analysis to observe the signal. Which significance do you get?