MadAnalysis 5 tutorial

FeynRules/MadGraph School on Collider Phenomenology 2018
19-23 November 2018, Hefei (China)

Outlines

1. Requirements for the tutorial

2. Designing a simple analysis with the normal mode

3. Applying LHC recast analyses on a signal sample

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1. Requirements for the tutorial

Installation of tools on your machine

1. **Installing the new release of MadAnalysis 5**

   - *Downloading the tarball from the webpage:* *https://launchpad.net/madanalysis5/trunk/v1.6/+download/MA5_v1.7beta.tgz*
   - *Untar the tarball*

```
bash> tar xzf MA5_v1.7beta.tgz
```

   - *Executing MadAnalysis 5*

```
bash> cd madanalysis5
bash> ./bin/ma5
```

2. **Installing Delphes for MadAnalysis 5**

```
ma5> install delphes
```

3. **Installing the PAD (Physics Analysis Database) interface**

```
ma5> install PAD
```

4. **Piece of advice: installing zlib if not found**

```
ma5> install zlib
```

1. Requirements for the tutorial

Samples produced during the MadGraph tutorial

1. **Signal sample: monojet (jet+missing energy)**
   - *MG command line:* generate p p > xd xd~ j
   - *Number of events: at least 10,000*
   - *File format: LHE, HEPMC*

2. **Background sample: neutrino + jets**
   - *MG command line:* generate p p > vl vl~ j
   - *Number of events: at least 10,000*
   - *File format: LHE, HEPMC*

If you did have the time to produce these samples, do not worry!

These samples can be found here:

https://indico.ihep.ac.cn/event/7822/page/8

1. Requirements for the tutorial

Documentation

Reference card of MadAnalysis 5 v1.6 is available and can help you for defining an analysis.

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2. Defining an analysis with the normal mode

First plots

- Import your samples LHE format
- Plotting a NPID histogram (multiplicity of each particle identity)
- Plotting MET
- Set the integrated luminosity to 65 fb^{-1} (end of LHC run II)

Do the same for HEPMC files and compare the results.

Starting MadAnalysis 5 for parton level studies

```
bash> ./bin/ma5
```

Starting MadAnalysis 5 for hadron level studies

```
bash> ./bin/ma5 -H
```

2. Defining an analysis with the normal mode

First plots - SOLUTION

```
ma5> import signal.lhe.gz as mySignal
ma5> import background.lhe.gz as myBackground
ma5> set mySignal.type = signal
ma5> set myBackground.type = background

ma5> define invisible = 52 -52 invisible

ma5> plot NPID
ma5> plot MET [logy]

ma5> set main.lumi = 65
ma5> submit
```

Can be avoided if you import the UFO model

```
ma5> import mymodel_UFO
```

2. Defining an analysis with the normal mode

ROOT files production

- From HEPMC files, produce ROOT files by applying Delphes with « standard » CMS simulation. No pile-up simulation.
- Check with the previous scripts the content of your ROOT sample.

Starting MadAnalysis 5 for reconstruction-level studies

```
bash> ./bin/ma5 -R
```

Applying Delphes over your events from MadAnalysis 5 console

```
ma5> define invisible = 52 -52 invisible
ma5> set main.fastsim.package = delphes
ma5> set main.fastsim.detector = cms
ma5> set main.fastsim.output = true
ma5> import signal.hepmc
ma5> submit
```

ROOT file will be here: ANALYSIS_X/Output/_defaultset/RecoEvents0_0/DelphesEvents.root

2. Defining an analysis with the normal mode

Defining an analysis from ROOT files

1. Searching for the most discriminating variables and defining a simple cut-and-count selection.

2. Creating 4 several regions:
   - « At least one b-tag jet » and « light jets »
   - MET < 250 GeV and MET > 250 GeV

Some observables to study

Leptonic activity	Isolated lepton multiplicity
Hadronic activity	Jet multiplicity
	THT (Total Hadronic Transverse Energy)
	Transverse momentum of all jets, of the leading jet, of the sub-leading jet, …
	B-tagging
Angles	ΔR(MET,j), ΔΦ(MET,j)

Defining an analysis from ROOT files - SOLUTION

```
ma5> # ******PLOTS******

ma5> define l = l+ l-
ma5> plot N(l)

ma5> define j = j b
ma5> plot N(j)
ma5> plot THT
ma5> plot PT(j)
ma5> plot PT(j[1])

ma5> plot N(b)
ma5> plot PT(b)
ma5> plot PT(b[1])

ma5> plot DELTAR(met,j[1])
ma5> plot DPHI_0_2PI(met,j[1])
```

Defining an analysis from ROOT files - SOLUTION

```
ma5> # ******SIGNAL REGIONS******
ma5> define_region b_lowMET
ma5> define_region b_highMET
ma5> define_region j_lowMET
ma5> define_region j_highMET

ma5> select N(b)>=1 { b_lowMET  b_highMET }
ma5> select N(b)==0 { j_lowMET  j_highMET }
ma5> select MET>=250{ j_highMET b_highMET }
ma5> select MET<250 { j_lowMET  b_lowMET  }
```

Defining an analysis from ROOT files - SOLUTION

```
ma5> # ******SOME CUTS******
```

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3. **Applying LHC recast analyses on a signal sample**

3. Applying LHC recast analyses

Goal: constraints on your process by the ATLAS monojet analysis ATLAS-EXOT-2015-03

Have a look on the PAD (Physics Analysis Database) of the validation card of the analysis implementation

http://madanalysis.irmp.ucl.ac.be/wiki/PublicAnalysisDatabase

3. Applying LHC recast analyses

Reinterpretation step-by-step:

- Opening a MadAnalysis 5 session @ the reconstruction level

```
bash> ./bin/ma5 -R
```

- Activating the « recast » mode

```
ma5> set main.recast = on
```

- Importing your signal sample (HEPMC format)

```
ma5> import *.hepmc.gz
```

- Launching the reinterpretation

```
ma5> submit
```

3. Applying LHC recast analyses

Launching the analysis ATLAS-EXOT-2015-03 on your signal:

- Editing the recasting Card

```
MA5: Would you like to edit the recasting Card ? (Y/N)
Answer: Y
```

- Selecting ONLY the ATLAS monojet analysis ATLAS-EXOT-2015-03 analysis

```
# AnalysisName          PADType    Switch    DelphesCard
cms_top_17_009           v1.2       off    delphes_card_cms_top_17_009.tcl        # CMS   - 13 TeV - 4 top ana
CMS_EXO_16_012_2gamma    v1.2       off    delphes_card_cms_exo_16_012.tcl        # CMS   - 13 TeV - Mono-Higg
cms_sus_17_001           v1.2       off    delphes_card_cms_exo_16_010.tcl        # CMS   - 13 TeV - stops in
CMS_SUS_16_052           v1.2       off    delphes_card_cms_SUS_16_052.tcl        # CMS   - 13 TeV - SUSY 1 le
ATLAS_SUSY_16_07         v1.2       off    delphes_card_ATLAS_1604_07773.tcl      # ATLAS - 13 TeV - Multijet
ATLAS_EXOT_2016_32       v1.2       off    delphes_card_atlas_2016_32.tcl         # ATLAS - 13 TeV - Monophoto
ATLAS_1711_03301         v1.2       on     delphes_card_ATLAS_1711_03301.tcl      # ATLAS - 13 TeV - Monojet
ATLAS_CONF_2016_086      v1.2       off    delphes_card_ATLAS_CONF_2016_086.tcl   # ATLAS - 13 TeV - Dark matt
```

- Detector simulation + Reinterpretation ongoing. Be patient please.

3. Applying LHC recast analyses

Opening the results

At the end of the reinterpretation process, results are gathered into a file called « CLs_output_summary.dat ».
Open the file for getting the excluded cross-section @ CL=95%.

# dataset	analysis name	signal region	sig95(exp)	sig95(obs)	||	efficiency	stat. unc.	sys
defaultset	ATLAS_1604_07773	EM1	4.8706612	5.1880773	||	0.0529692	0.0341248	0.0
defaultset	ATLAS_1604_07773	EM2	2.3853053	1.8139249	||	0.0694817	0.0387413	0.0
defaultset	ATLAS_1604_07773	EM3	1.0788100	0.6677819	||	0.1020777	0.0461277	0.0
defaultset	ATLAS_1604_07773	EM4	0.2632191	0.3037660	||	0.3445360	0.0724050	0.0
defaultset	ATLAS_1604_07773	EM5	0.2899671	0.4168377	||	0.1198082	0.0494776	0.0
defaultset	ATLAS_1604_07773	EM6	4.1283192	2.9171533	||	0.0048845	0.0106224	0.0
defaultset	ATLAS_1604_07773	EM7	11.7875544	15.2956134	||	0.0012613	0.0054078	0.0
defaultset	ATLAS_1604_07773	IM1	0.8393238	0.7617653	||	0.6950184	0.0701474	0.0
defaultset	ATLAS_1604_07773	IM2	0.5545031	0.4478380	||	0.6420493	0.0730420	0.0
defaultset	ATLAS_1604_07773	IM3	0.3738453	0.3294120	||	0.5725676	0.0753744	0.0
defaultset	ATLAS_1604_07773	IM4	0.2708652	0.3210029	||	0.4704898	0.0760482	0.0
defaultset	ATLAS_1604_07773	IM5	0.4089076	0.4915413	||	0.1259540	0.0505533	0.0
defaultset	ATLAS_1604_07773	IM6	0.4738019	3.8653407	||	0.0061458	0.0119077	0.0