

# MC4BSM 2015 - CheckMATE Tutorial

## 1 Introduction

This tutorial will guide you through some practical examples to learn how CheckMATE works [1]. We have chosen the reference model [2] which you will consecutively analyse. In addition to CheckMATE, we will also run some other tools that are useful for collider phenomenology [3, 4].

## 2 Virtual Machine Setup

In order to follow the instructions of the tutorial, you have to use a virtual machine that we have already set up for you. The machine makes it easy to access a variety of different tools without requiring you to install them first. That way we can focus more on the actual physics. To install and run the virtual machine, you have to follow the instructions at

[http://checkmate.hepforge.org/online\\_tutorial/web/vm.php](http://checkmate.hepforge.org/online_tutorial/web/vm.php)

## 3 Testing the CheckMATE installation

After the virtual machine is set up, we do a simple test in order to check that CheckMATE works. You should find the CheckMATE executable in the directory

```
/home/checkmate/tools/checkmate/bin
```

In the same folder you should find an example parameter file `testparam.dat` with a minimally working example. If you look into the file, you will find the following

```
## General Options
[Mandatory Parameters]
Name: My_New_Run
Analyses: atlas_conf_2013_047

[Optional Parameters]

## Process Information (Each new process 'X' must start with [X])
[gluinogluino]
XSect: 3.53*FB
XSectErr: 1e-5*PB
Events: testfile.hep
```

Some general options and parameters are fixed in the text file which are necessary in order to run CheckMATE.

Running the example with the event file `testfile.hep` provided by the Checkmate installation should, after confirmation and some intermediate output, produce the following result (which should not be surprising as the test events effectively do not contain any signal events):

```
[...]
Test: Calculation of  $r = \text{signal}/(95\% \text{CL limit on signal})$ 
```

```
Result: Allowed
Result for r: r_max = 0.0
SR: atlas_conf_2013_047 - AL
```

The most important result is given by the `Result:` line, which will either state `Allowed` or `Excluded`. This statement alone allows the user to quickly perform simple tests on his model of interest.

## 4 Testing the reference BSM model

In the previous exercises, you should have learned how to implement the reference model, which is a simple extension of the SM, into FeynRules [5] and to obtain a corresponding model file for Madgraph. In the following, we will generate enough events with Madgraph in order to test the model point with CheckMATE. Run the Madgraph binary in

```
/home/checkmate/tools/mg5_amc/bin
```

First we have to load the model file

```
import model MC4BSM_2012_UF0.tar
```

We want to instruct Madgraph to generate the following process

$$pp \rightarrow U\bar{U}, \tag{1}$$

where  $U \rightarrow u\phi_1$  and  $\bar{U} \rightarrow u\phi_2$  with  $\phi_2 \rightarrow e^+e^-\phi_1$ . First we define the two objects

```
define l = e+ e-
define lv = ev ev~
```

and then generate the process

```
generate p p > uv uv~, uv > u p1, (uv~ > u~ p2, (p2 > l lv, lv > l p1))
```

and finally create the output directory.

```
output /home/checkmate/tutorial/MC4BSM/mc4bsm
```

Within the output directory there is a designated folder that contains all files where user accessible parameters can be defined. It is located under

```
/home/checkmate/tutorial/MC4BSM/mc4bsm/Cards.
```

We want to keep the default parameters of the model, but we have to fix some parameters for the event generation which are given in the

```
run_card.dat
```

We want to test the model point at the LHC with a beam energy of 8 TeV and thus changing the value in the corresponding card.

With the setup files ready, go back to the MadGraph terminal, type

```
launch /home/checkmate/tutorial/MC4BSM/mc4bsm
```

answer 1 afterwards to activate pythia=ON and then hit enter twice to start the event generation. It should take a couple of minutes to complete. You can simply close the firefox window that pops up automatically. As soon as MadGraph is done, run gunzip

```
/home/checkmate/tutorial/MC4BSM/mc4bsm/Events/run_01/tag_1_pythia_events.hep.gz
```

to unpack the compressed event file. Also, write down the cross section MadGraph quotes at the very end.

Since the final state includes 2 leptons, jets and missing transverse energy, we want to test the model point with the LHC search `atlas_conf_2013_089` (2 leptons + jets + MET) [6].

We make a copy of the `testparam.dat` card in the binary directory of CheckMATE. We modify the relevant entries in the CheckMATE card and run CheckMATE again and then will see if the model point is excluded or not.

## References

- [1] M. Drees, H. Dreiner, D. Schmeier, J. Tattersall and J. S. Kim, *Comput. Phys. Commun.* **187** (2014) 227 [arXiv:1312.2591 [hep-ph]].
- [2] S. Ask, N. D. Christensen, C. Duhr, C. Grojean, S. Hoeche, K. Matchev, O. Mattelaer and S. Mrenna *et al.*, arXiv:1209.0297 [hep-ph].
- [3] J. Alwall, R. Frederix, S. Frixione, V. Hirschi, F. Maltoni, O. Mattelaer, H.-S. Shao and T. Stelzer *et al.*, *JHEP* **1407** (2014) 079 [arXiv:1405.0301 [hep-ph]].
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- [5] A. Alloul, N. D. Christensen, C. Degrande, C. Duhr and B. Fuks, *Comput. Phys. Commun.* **185** (2014) 2250 [arXiv:1310.1921 [hep-ph]].
- [6] Search for strongly produced supersymmetric particles in decays with two leptons at 8 TeV <https://cds.cern.ch/record/1595272?ln=es>