MadGraph Tutorial III

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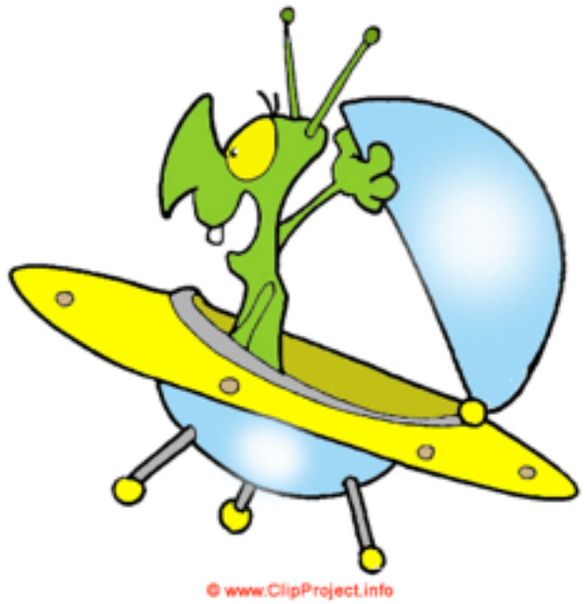
Plan

- Saturday: MadGraph5
  - ➡ Install MadGraph 5
  - ➡ Learn the various syntax
- Yesterday: FeynRules
  - ➡ Install FeynRules
  - ➡ Create your own Model
- Today: BSM
  - ➡ Use the FR model to do some phenomenology

BSM in MadGraph5



- MG5 relies on UFO and ALOHA
  - ➡ Basically All BSM supported in MG5
  - ➡ Field supported: 0, 1/2, 1, 3/2, 2
  - ➡ Any number of particles in the interactions
  - ➡ Color representation: 0, 3, 6, 8
    - ✦ support of Epsilon structure
  - ➡ Multi-fermion operator (But no majorana/flow violation in multi-fermion operator)
  - ➡ custom propagator supported
  - ➡ Form Factor allowed
  - ➡ Assume:
    - ✦ CPT Invariance
    - ✦ Local Operator

arXiv:1108.2041

FeynRules

- If you didn't have your own model. Don't hesitate to download the solution on the indico or ask Celine for Bluetooth connection.

Exercise I: Check the model validity

- Check the model validity:
  - ➡ check p p > uv uv~
  - ➡ check p p > ev ev~
  - ➡ check p p > t t~ p1 p2
  - ➡ ...

- Check with MG the width computed with FR:
  - ➡ generate uv > all all; output; launch
  - ➡ generate ev > all all; output; launch
  - ➡ generate p1 > all all; output; launch
  - ➡ generate p2 > all all; output; launch

FR Number
0.0706 GeV
0.00497 GeV
0 GeV
0.0224 GeV

- Muv = 400 GeV Mev = 50 GeV λ=0.1
- m1 = 1GeV m2 = 100GeV m12 = 0.5 GeV

Exercise II:

- Compute cross-section and distribution
  - ➡ uv pair production with decay in top and Φ_1/Φ_2 (semi leptonic decay for the top
- Hint: The width of the new physics particles has to be set correctly in the param_card.
  - ➡ You can either use "Auto" arXiv:1402.1178
  - ➡ or use the value computed in exercise 1
- Hint: For sub-decay, you have to put parenthesis:
  - ➡ example:

    p p > t t~ w+, (t > w+ b, w+ >e+ ve), (t~ > b~ w-, w- > j j), w+ > l+ vl

Too Slow?

- Use MadSpin! arXiv:1212.3460
  - ➡ Use Narrow Width Approximation to factorize production and decay
- instead of
  - ➡ p p > t t~ w+, (t > w+ b, w+ >e+ ve), (t~ > b~ w-, w- > j j), w+ > l+ vl
- Do
  - ➡ p p > t t~ w+
- At the question:

```
The following switches determine which programs are run:
 1 Run the pythia shower/hadronization:                    pythia=OFF
 2 Run PGS as detector simulator:                             pgs=OFF
 3 Run Delphes as detector simulator:                      delphes=NOT INSTA
 4 Decay particles with the MadSpin module:                madspin=OFF
 5 Add weight to events based on coupling parameters:     reweight=OFF
  Either type the switch number (1 to 5) to change its default setting,
  or set any switch explicitly (e.g. type 'madspin=ON' at the prompt)
  Type '0', 'auto', 'done' or just press enter when you are done.
 [0, 1, 2, 4, 5, auto, done, pythia=ON, pythia=OFF, ... ][60s to answer]
```

- At the next question edit the madspin_card and define the decay

Exercise III

- Do the same for the top pair production background.
  - ➡ Compare the distributions
- Generate Signal + Background plot
  - ➡ Do this for different value of the coupling
  - ➡ Propose a strategy of measurement

Exercise IV

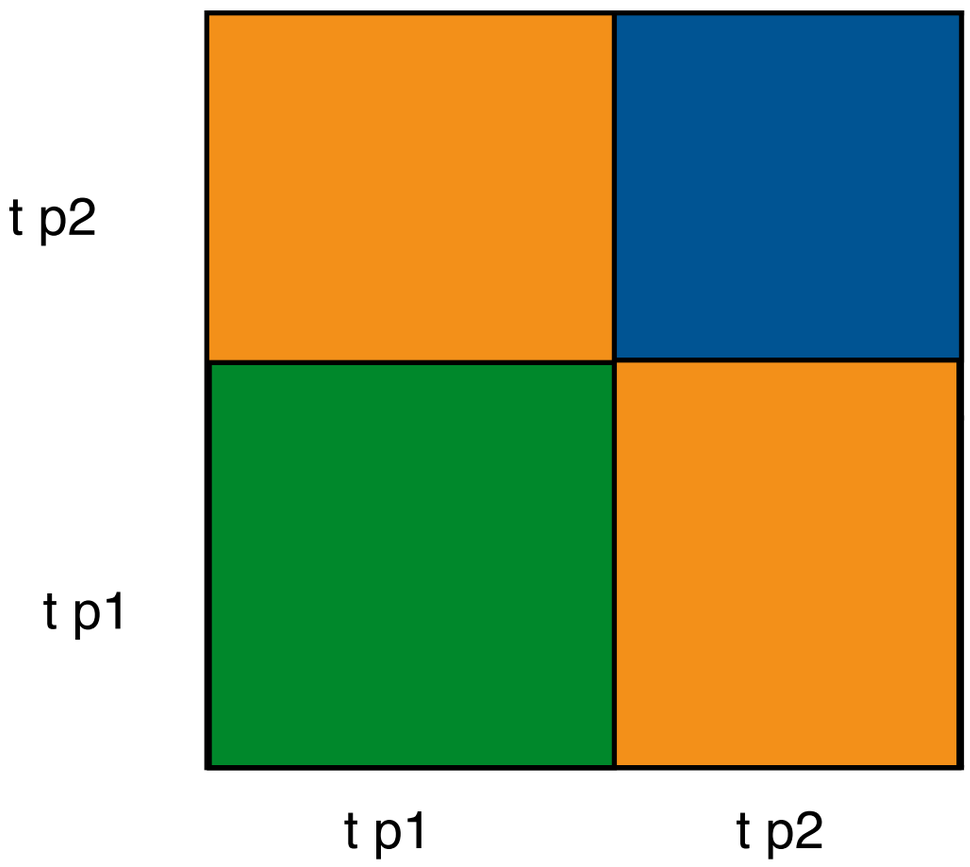
- Have Fun!!!
  - ➡ Looks at your strategy after shower/detector simulation
  - ➡ Generate the background at NLO
  - ➡ Compute expected exclusion limit
- Hint for shower/detector:
  - ➡ install pythia-pgs
  - ➡ install Delphes
- Hint for NLO:
  - ➡ generate p p > t t~ [QCD]
    - ✦ Use MadSpin for the decay of the top pair.

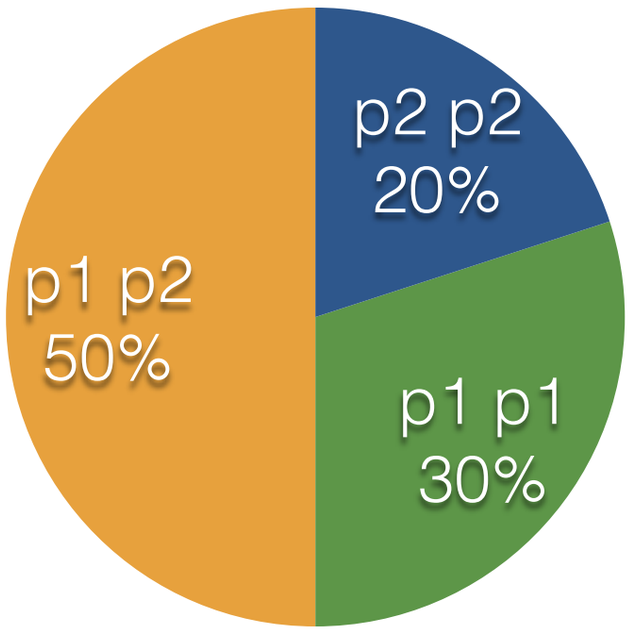
WORK

- Take the model + those slides:
  -> Celine
- use the check command and a couple of process
- check the FR formula for two body decay
- compute cross-section for uv pair production.
  decay in top, Φ_1 (top in semi-leptonic)
- Compare with the top pair irreducible background
- Have fun!
  - ➡ pythia/Delphes
  - ➡ NLO
  - ➡ Exclusion limit

UV branching ratio

```
DECAY   9000008    7.063710e-02
#   BR                NDA   ID1     ID2    ...
    5.439901e-01     2     9000006   6 # 0.0384258854562
    4.560099e-01     2     9000007   6 # 0.0322112126178
#
```

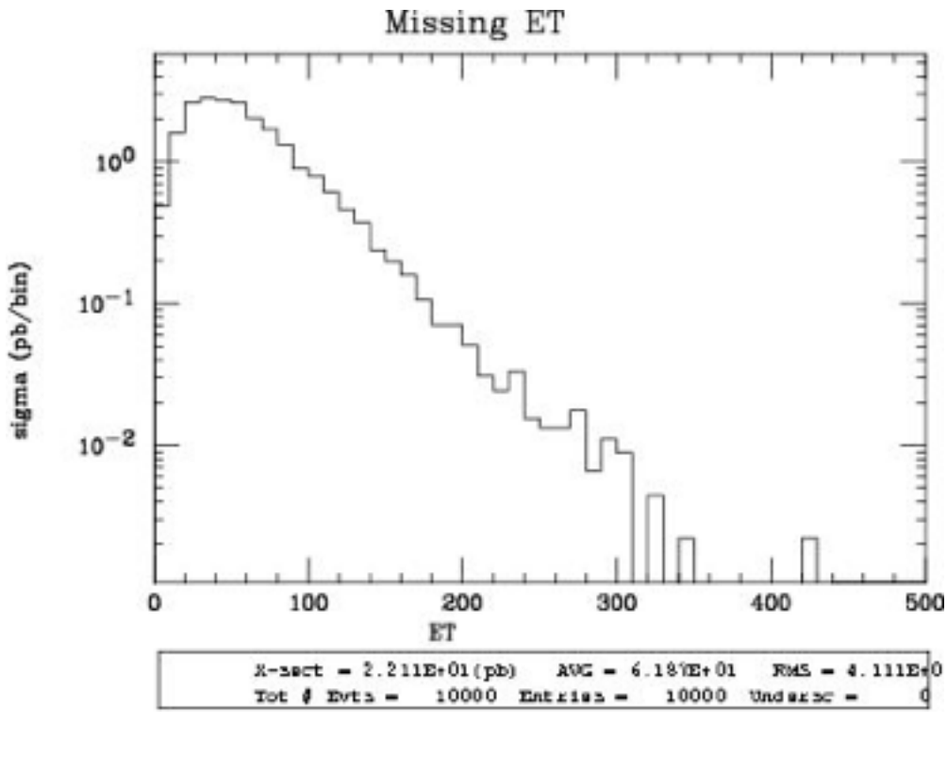




p l p l

p p > t t~, (t > w+ b, w+ > j j),(t~ > w- b~, w- > e- ve~)

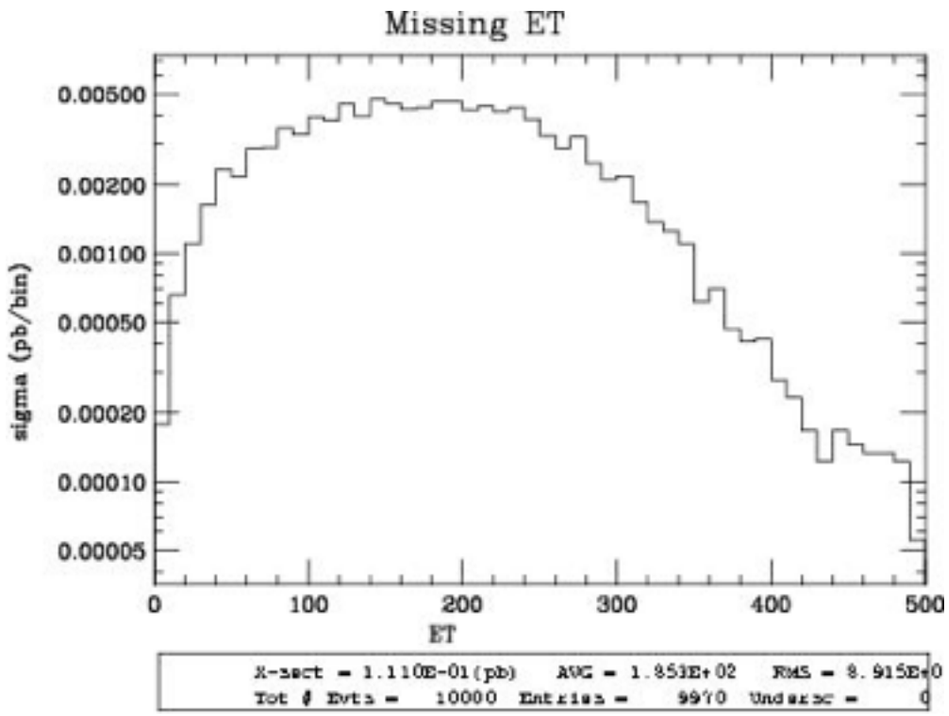
Collider	Banner	Cross section (pb)
p p 6500 x 6500 GeV	tag_1	22.11 ± 0.073



p p > t t~ p1 p1,

p p 6500 x 6500 GeV	tag_1	0.1111 ± 0.00048

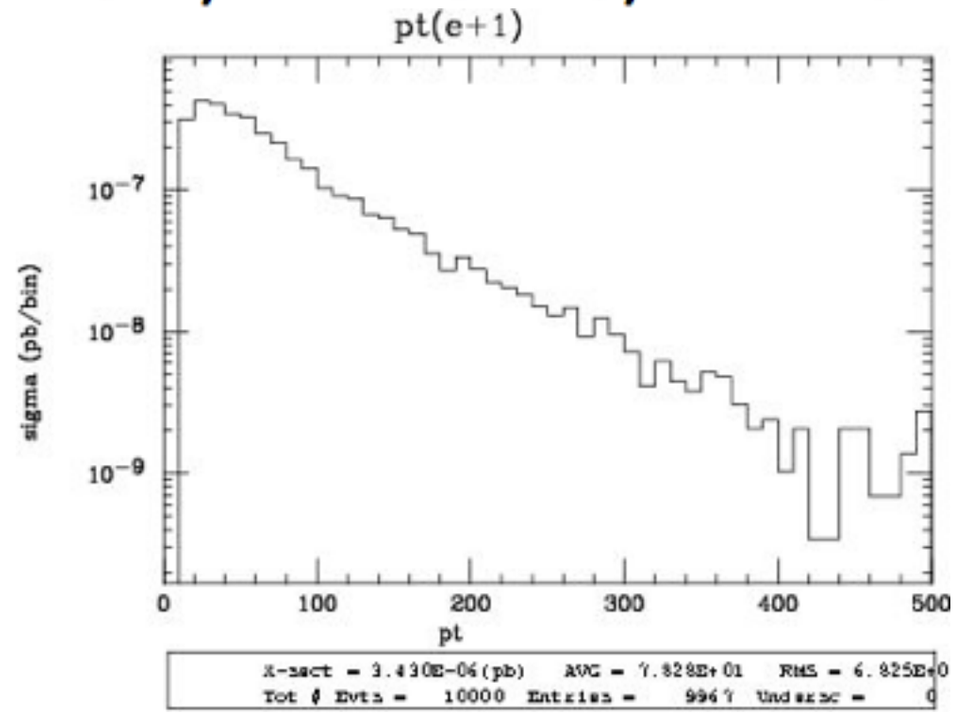
Note: you need to add p1 to the list of unobserved particles for the plot



p1 p2

```
p p > t t~ w+ w-, t > b j j, t~ > b~ e- ve~ , w+ > e+ ve, w- > e- ve~
```

Collider	Banner	Cross section (pb)
p p 6500 x 6500 GeV	tag_1	3.43e-06 ± 9.2e-09




```
p p > t t~ p1 p2, t > b j j, t~ > b~ e- ve~, (p2 > ev e+, ev > e- p1)
```

p p 6500 x 6500 GeV	tag_1	0.0576 ± 0.00021