

MadGraph Tutorial III

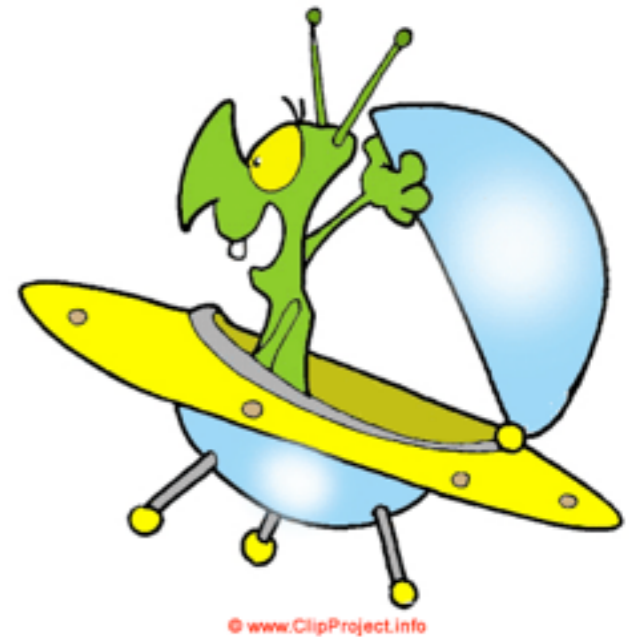
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Plan

- 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 $p p \rightarrow uv \bar{u} \bar{v}$
 - ➔ check $p p \rightarrow e \nu \bar{e} \bar{\nu}$
 - ➔ check $p p \rightarrow t \bar{t} p_1 p_2$
 - ➔ ...
- Check with MG the width computed with FR:
 - ➔ generate $uv \rightarrow$ all all; output; launch
 - ➔ generate $e\nu \rightarrow$ all all; output; launch
 - ➔ generate $p_1 \rightarrow$ all all; output; launch
 - ➔ generate $p_2 \rightarrow$ all all; output; launch

FR Number

0.0706 GeV

0.00497 GeV

0 GeV

0.0224 GeV

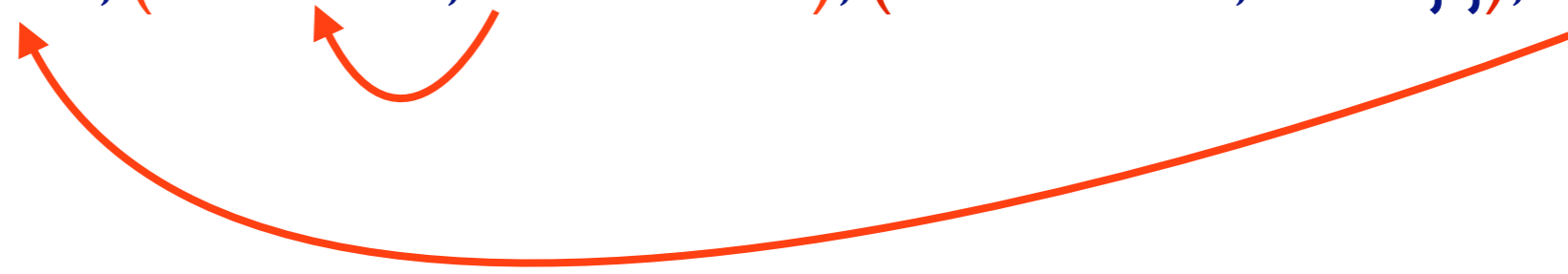
● $M_{uv} = 400 \text{ GeV}$ $M_{e\nu} = 50 \text{ GeV}$ $\lambda = 0.1$

● $m_1 = 1 \text{ GeV}$ $m_2 = 100 \text{ GeV}$ $m_{12} = 0.5 \text{ GeV}$

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:

$$p p \rightarrow t \bar{t} w^+, (t \rightarrow w^+ b, w^+ \rightarrow e^+ \nu_e), (\bar{t} \rightarrow \bar{b} w^-, w^- \rightarrow j \bar{j}), w^+ \rightarrow l^+ \nu_l$$



- Use MadSpin! [arXiv:1212.3460](https://arxiv.org/abs/1212.3460)
 - ➔ Use Narrow Width Approximation to **factorize** production and decay
- instead of
 - ➔ $p p \rightarrow t \bar{t} w^+, (t \rightarrow w^+ b, w^+ \rightarrow e^+ \nu_e), (t \rightarrow b \bar{w}^-, w^- \rightarrow j j), w^+ \rightarrow l^+ \nu_l$

- Do
 - ➔ $p p \rightarrow t \bar{t} w^+$

- 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

How to have plot for MadSpin

- Sorry this is a small bug...
 - ➔ `$> cd $PROCESSSDIR/Events/run_01_decayed_1`
 - ➔ `$> touch events.lhe`
 - ➔ `$> cd ../..`
 - ➔ `$> ./bin/madevent`
 - ➔ `plot run_01_decayed_1`

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 $p p \rightarrow t \bar{t}$ [QCD]
 - ◆ Use MadSpin for the decay of the top pair.

WORK

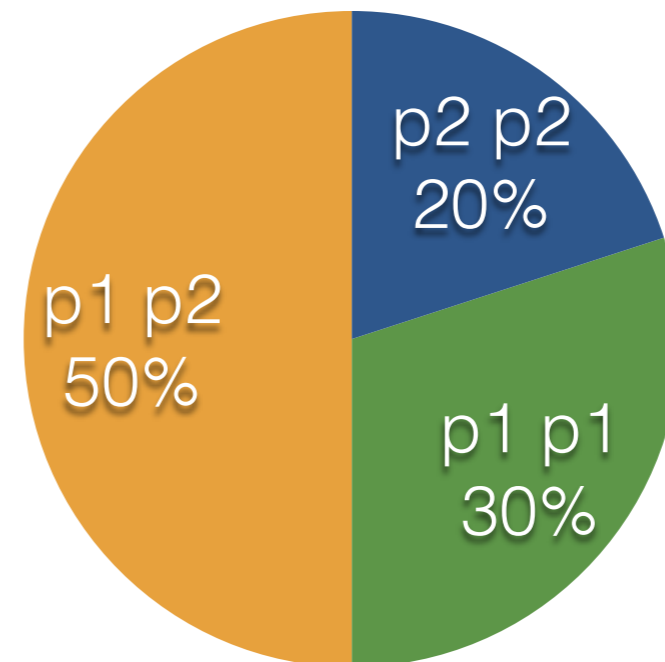
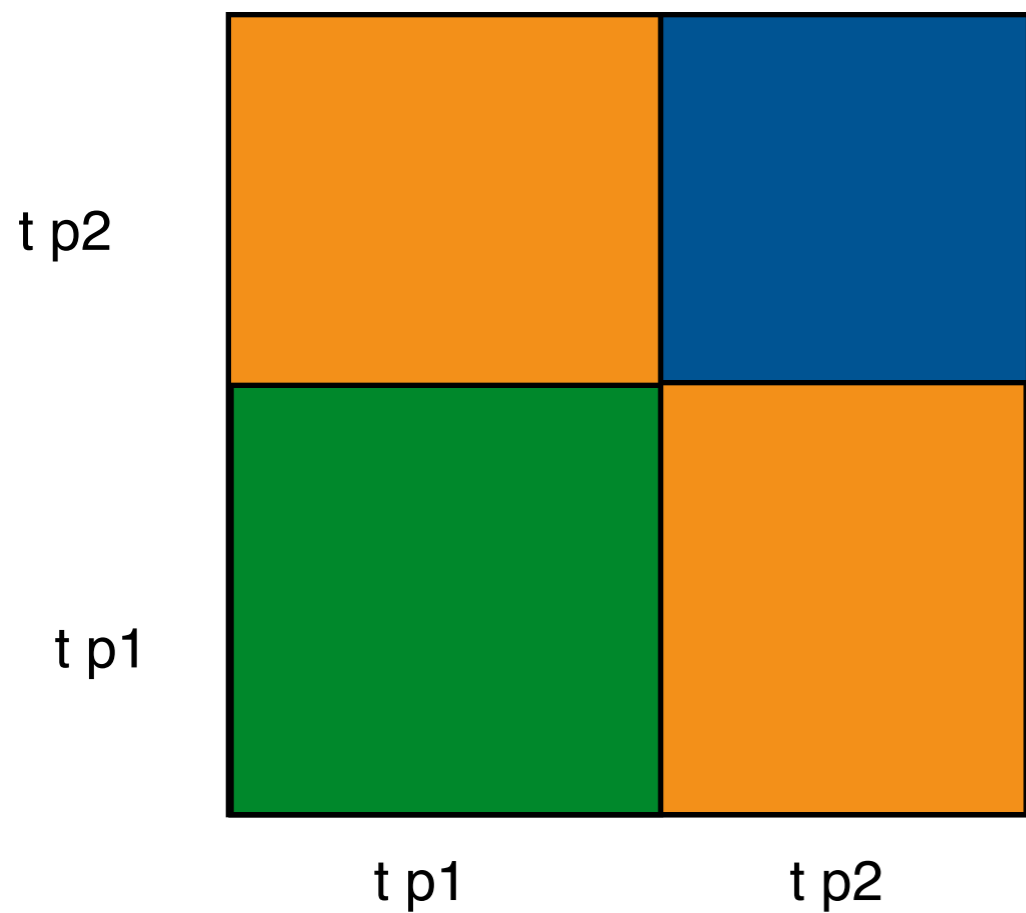
- Take the model + those slides:
-> Celine
- use the check command and a couple of process
- check the FR formula for two body decay
- compute cross-section for uv pair production.
decay in top, Φ_1 (top in semi-leptonic)
- Compare with the top pair irreducible background
- Have fun!
 - ➔ pythia/Delphes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

UV branching ratio

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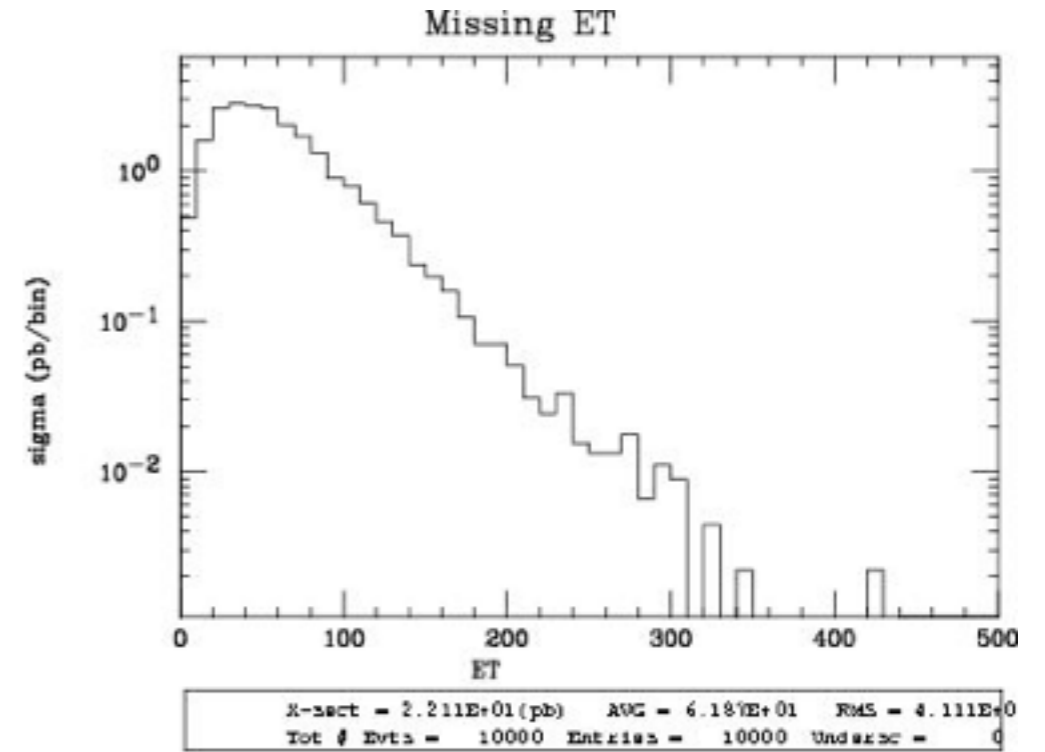
DECAY  9000008      7.063710e-02
#  BR              NDA  ID1      ID2      ...
      5.439901e-01  2    9000006  6  #  0.0384258854562
      4.560099e-01  2    9000007  6  #  0.0322112126178
"

```



$pp > t t^-, (t > w^+ b, w^+ > j j), (t^- > w^- b^-, w^- > e^- \nu e^-)$

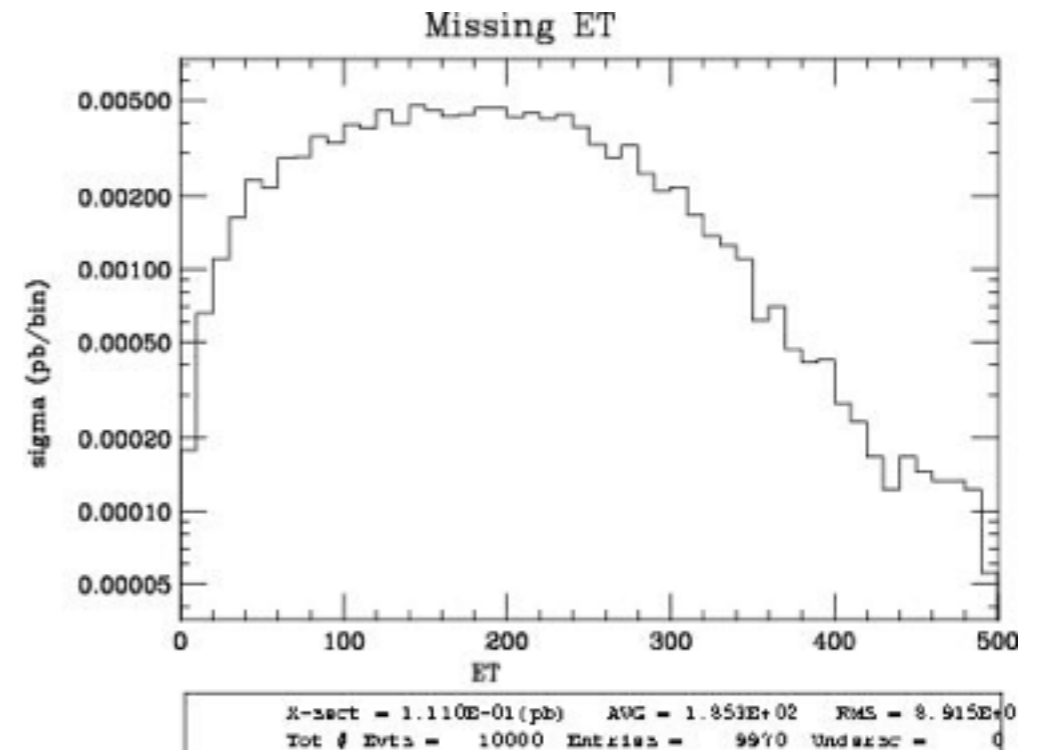
Collider	Banner	Cross section (pb)
pp 6500 x 6500 GeV	tag_1	22.11 ± 0.073



$pp > t t^- p1 p1,$

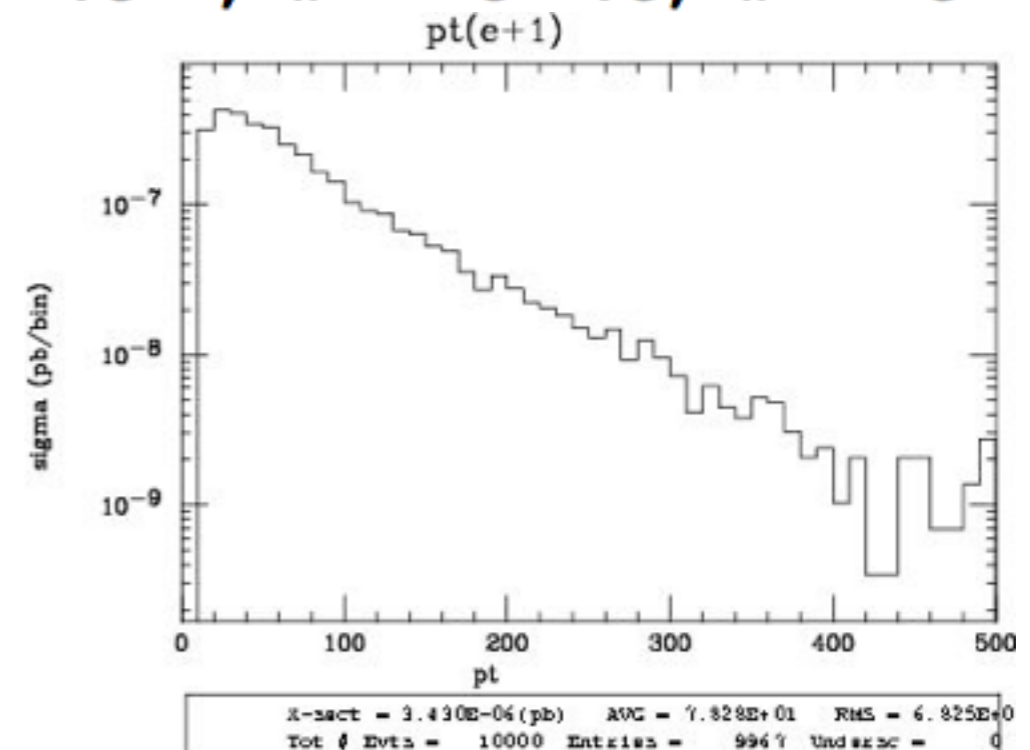
pp 6500 x 6500 GeV	tag_1	0.1111 ± 0.00048
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Note: you need to add p1 to the list of unobserved particles for the plot



$p p > t t^{\sim} w^{+} w^{-}, t > b j j, t^{\sim} > b^{\sim} e^{-} \nu e^{\sim}, w^{+} > e^{+} \nu e^{\sim}, w^{-} > e^{-} \nu e^{\sim}$

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



$p p > t t^{\sim} p1 p2, t > b j j, t^{\sim} > b^{\sim} e^{-} \nu e^{\sim}, (p2 > e \nu e^{+}, e \nu > e^{-} p1)$

p p 6500 x 6500 GeV	tag_1	0.0576 ± 0.00021
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