The new FeynRules interface : an automation of the effective theories implementation in FeynArts

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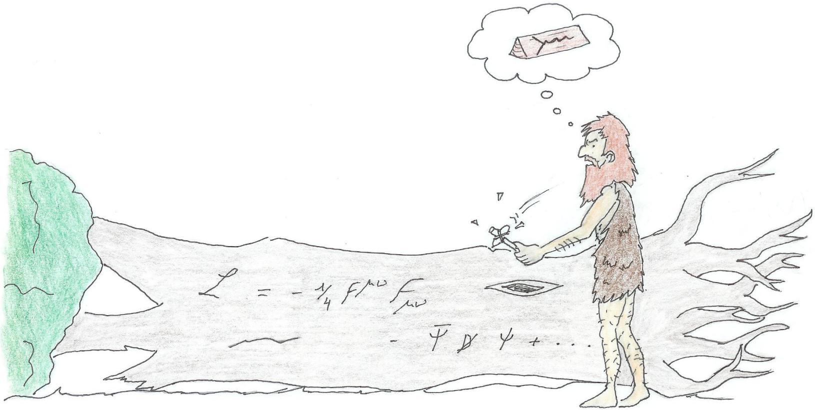
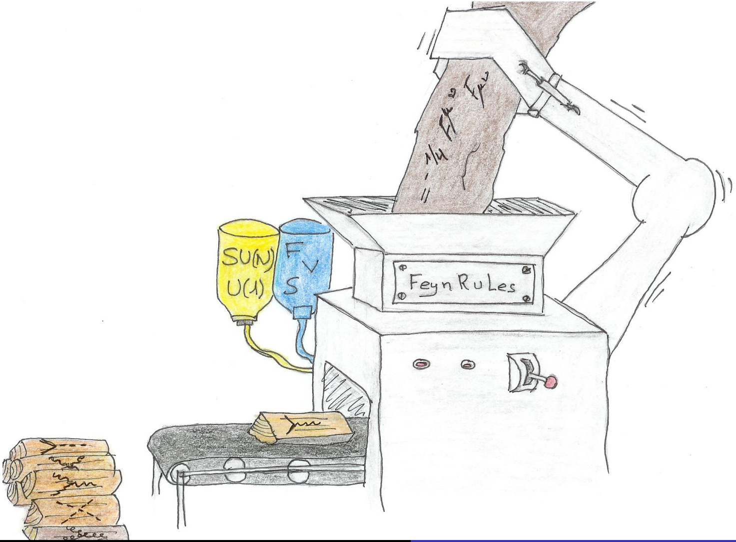
Outline

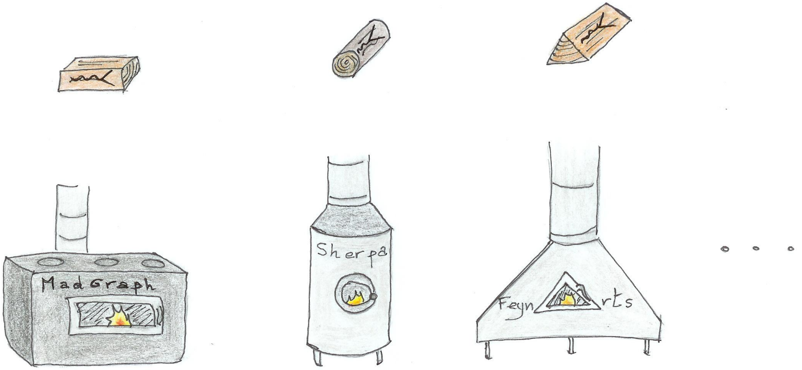
It took a long long long time



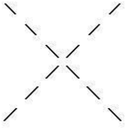
Welcome in the FeynRules era



For each tool, the right input



The FeynArts inputs



$$= A \times 1 + B\, p_1 \cdot p_2 + \ldots$$
$$= (A\ B\ \ldots) . \begin{pmatrix} 1 \\ p_1 \cdot p_2 \\ \ldots \end{pmatrix}$$

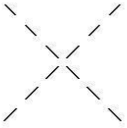
$\begin{pmatrix} 1 \\ p_1 \cdot p_2 \\ \ldots \end{pmatrix}$: Generic coupling $\in$ generic file

$(A\ B\ \ldots)$: Coupling matrix $\in$ model file

The old interface

Based on lorentz.gen (default FeynArts generic file)
$\Rightarrow$ Only the lorentz structures of the SM

For example, only $A \times 1$ is transmitted to FeynArts in



$$
\begin{aligned}
&= A \times 1 + B\, p_1 \cdot p_2 + \ldots \\
&= (A \; B \; \ldots) . \begin{pmatrix} 1 \\ p_1 \cdot p_2 \\ \ldots \end{pmatrix}
\end{aligned}
$$

Motivations

- Many (new) models are effective theories : new lorentz structures in their vertices.
- FeynRules can generate these new vertices.
- FeynArts/FormCalc can handle more complicated structures.
- All you need is the generic file.

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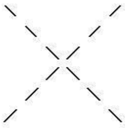
How does it work

1. Extract all the lorentz structures from the Feynman rules to build the generic couplings
2. Compute the associated coupling matrices
3. Write the generic and model files



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\begin{aligned}
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&= (A \;\; B \;\; \dots) \, . \begin{pmatrix} 1 \\ p_1 \cdot p_2 \\ \dots \end{pmatrix}
\end{aligned}
$$

How to use it

1. You need the FeynRules model file (lists of parameters, particles and gauge groups and Lagrangian(s))
2. You load FeynRules, the model and call WriteFeynArtsOutput
3. It creates a directory with
   - the FeynArts model file
   - the FeynArts generic file
4. You put these 2 files in the FeynArts models directory
5. You feed FeynArts with these files
   InsertFields[topo, {P_1, P_2} -> {P_3, P_4, ...}, GenericModel -> "YourModel", Model -> "YourModel"]

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Validation : SILH

- Strongly interacting light Higgs (dimension 6 operators)
  G. F. Giudice, C. Grojean, A. Pomarol and
  R. Rattazzi,JHEP **0706**, 045 (2007)

- Analytic tests
  - Higgs decay witdhs at tree-level
    K. Hagiwara, R. Szalapski and D. Zeppenfeld, Phys. Lett. B
    318, 155 (1993)

- Using FeynArts and FormCalc
  - VVS ($p_i^\mu p_j^\nu$, $\eta^{\mu\nu} p_i \cdot p_j$)

Validation : Composite top

- Effective theory for a composite top (dimension 6 operators)
  C.D., J.-M. Gérard, C. Grojean, F. Maltoni, G. Servant, in preparation

- Analytic tests (Test of new SU(N) structures)
  - top pair production at tree-level

- Using FeynArts and FormCalc
  - FFV ($p^\mu\gamma_\pm$, $p_i \cdot p_j\gamma^\mu\gamma_\pm$, $p_i^\mu \not{p}_j\gamma_\pm$, $\gamma^\mu\not{p}$, $\gamma_\pm$)
  - FFVV ($\eta^{\mu\nu}\gamma_\pm$, $p^\nu\gamma^\mu\gamma_\pm$, $\eta^{\mu,\nu}\not{p}\gamma_\pm$, $\gamma^\mu\gamma^\nu\gamma_\pm$)

Validation : χPT

- Effective theory for light pseudocsalar mesons
  C. D. and J. M. Gérard, JHEP **0905**, 043 (2009)
- Analytic tests
  - masses, mixing and wave functions renormalization
  - $\eta' -> \eta\pi\pi$ at tree-level and at one-loop ($>$ 60 diagrams)
- Use FeynArts only (cut-off regularization)
  - SSSS ($p_i \cdot p_j$)
  - SSSSSS (1, $p_i \cdot p_j$)

Conclusion : Status

- A large number of new lorentz structures are already correctly transmitted to FeynArts/FormCalc.
- However, at this stage FormCalc cannot deal with 4-fermion operators (T. Hahn).
- Together with the new interface a new version of FormCalc will be released that allows to deal with 4-fermion operators as well.
- FeynArts/FormCalc, in conjunction with FeynRules, will then be a matrix element generator able to generate **any** matrix element (up to three loops) for **any** model directly from a Lagrangian.

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