MadGraph/MadEvent

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Monte Carlo School
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A mad team...

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- Michel Herquet (NIKHEF)
- Fabio Maltoni (CP3)
- Olivier Mattelaer (CP3)
- Tim Stelzer (UIUC)

More expected very soon!
What we will cover

- What is MadGraph/MadEvent (MG/ME)
- How to run the code
- Implementing New Models
- Merging for BSM
What we won’t cover

- Internal workings of the code
- Detailed off-line running
- Decay chains & advanced process syntax
- MadWeight, MadDipole, MadOnium, ...
First Contact
MG/ME describes the Hard interaction at LO

Interfaces to Parton Showering and Hadronization codes like Pythia or Herwig

Interface to fast detector simulation with PGS
The "big" picture of MG/ME

- **Model**
  - particles.dat
  - interactions.dat
  - couplings.f

- **Calculator**
  - proc_card
  - param_card
  - run_card
  - pythia_card
  - pgs_card

- **MG**
  - Feyn. diags.
  - HELAS amplitudes

- **ME**
  - Parton-level events

- **Pythia**
  - Hadron-level events

- **PGS**
  - Reconstructed Objects

- **Reconstructed Objects**
  - Parton-level rootfile/plots
  - Hadron-level rootfile/plots
  - Reconstructed Objects rootfile/plots

- **ExRootAnalysis**

- **MadAnalysis**
How to run the code?
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Let’s have a look on the web at any of the three on-line operational clusters

- [http://madgraph.phys.ucl.ac.be/](http://madgraph.phys.ucl.ac.be/)
- [http://madgraph.hep.uiuc.edu/](http://madgraph.hep.uiuc.edu/)
- [http://madgraph.roma2.infn.it/](http://madgraph.roma2.infn.it/)
Slightly more advanced...
New Physics

Besides the available Models:

- **SM** (incl. Higgs eff. coupl. to gluons)
- **MSSM** (CP & R-parity conserving)
- **2HDM** (Completely general, incl. FCNC’s and CP violation)
- **TopBSM** (spin-0,1,2 resonances in top pair production)

There are two ways of implementing New Physics

- **FeynRules**
- **Usermod**
BSM with FeynRules

- **FeynRules** is a Mathematica package to compute automatically Feynman Rules from any QFT Lagrangian.
- User friendly **MG/ME interface** already tested extensively
- More models available soon (UED, 3-site, Littlest Higgs, ...)
- Not only interface to MG/ME, but also **CalcHEP/CompHEP, FeynArts, Sherpa, ...**
  - Allows to use best available Monte Carlo for the job without redoing the model implementation
- **Best option** for the implementation of realistic models (consistency, validation, ...)

More info at
http://feynrules.phys.ucl.ac.be

C. Duhr & N. Christensen
FeynRules interface

Lagrangian

FeynRules

MG interface

Model parameters

particles.dat
interactions.dat
couplings.f

Model

Calculator

proc_card
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UsrMod2

- UsrMod is a set of Python scripts to allow users to implement easily a few modifications to an existing MG/ME model (add particles, interactions, ...)
- Full support of all the models produced with FeynRules
- Best method for minor changes to existing models, i.e., for the study of a given signature, or when Mathematica is not available
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Solution:
One parton $\Leftrightarrow$ one jet

Define cut-off to separate ME and PS and use a merging prescription for the intermediate region (e.g. $k_T$MLM).
Matching/Merging

- Matching/Merging
- Parton Showers
- Hard interaction

Matrix elements and Parton Showers are complementary, but we need to avoid possible double counting.

Solution:
- One parton → one jet
- Define cut-off to separate ME and PS and use a merging prescription for the intermediate region (e.g. $k_T$ MLM)

It's working!
- Different multiplicities add up to a single observation.

Diagrams by MadGraph:
1. $u \bar{d} \rightarrow e^+ v e$
2. $u \bar{d} \rightarrow e^+ v e g$

Different multiplicities add up to a single observation.
Merging in BSM
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- Additional double counting due to **resonances**
  - e.g. squark pair production with additional jets
**Merging in BSM**

- Additional double counting due to *resonances*
  e.g. squark pair production with additional jets

- If gluinos on resonance, double counting with

Diagrams by MadGraph  g g -> dr dr~ d d~

```latex
\begin{align*}
\text{graph 9} & \quad 1 \quad \quad 2 \quad \quad 3 \quad \quad 4 \quad \quad 5 \quad \quad 6 \\
\text{graph 10} & \quad 1 \quad \quad 2 \quad \quad 3 \quad \quad 4 \quad \quad 5 \quad \quad 6 \\
\text{graph 11} & \quad 1 \quad \quad 2 \quad \quad 3 \quad \quad 4 \quad \quad 5 \quad \quad 6 \\
\text{graph 12} & \quad 1 \quad \quad 2 \quad \quad 3 \quad \quad 4 \quad \quad 5 \quad \quad 6 \\
\text{graph 13} & \quad 1 \quad \quad 2 \quad \quad 3 \quad \quad 4 \quad \quad 5 \quad \quad 6 \\
\text{graph 14} & \quad 1 \quad \quad 2 \quad \quad 3 \quad \quad 4 \quad \quad 5 \quad \quad 6 \\
\text{graph 15} & \quad 1 \quad \quad 2 \quad \quad 3 \quad \quad 4 \quad \quad 5 \quad \quad 6 \\
\text{graph 16} & \quad 1 \quad \quad 2 \quad \quad 3 \quad \quad 4 \quad \quad 5 \quad \quad 6 
\end{align*}
```
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Alwall, de Visscher, Maltoni
Conclusions

- MadGraph/MadEvent belongs to a complete chain from a BSM Lagrangian to collider data
- Efficient simulation from the web, or on your own machine(s)
- Wiki-page with more information, FAQ, talks, lectures, links, ...
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