MadGraph/MadEvent v 4

*From models to detectors in one go*

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Plan

- What is MG/MEv4? The “big picture”
- Structure flow chart
- A full step by step SM example
- A glance at new models
- Some other really new features in v4
- The future
What is exactly MG/ME v4

• MG/MEv4 is now a generic name for our full chain of tools allowing the user(s) to go directly from a given physics model to simulated events in a detector
• It “contains” MadGraphII, HELAS, MadEvent and interfaces to Pythia, PGS, ROOT and CMSSW
• The same chain can be used to generate (SM or BSM) signals and main SM backgrounds
• A complete web server oriented interface is available (different levels of user account)
• The computation itself can be done online or offline and on one CPU or on a large cluster
MG/ME Who's Who

• Main (original) authors: Fabio Maltoni (Prof. UCL) and Tim Stelzer (Prof. UIUC)

• Version 4 development team:
  • Johan Alwall (Post Doc, SLAC): SUSY, Int. to Pythia, CKKW and matching, ...
  • Pavel Demin (Post Doc, UCL): Int. to ROOT, automatic plotting
  • Simon de Visscher (Ph.D. UCL): 2HDM, User Model implementation
  • Rikkert Frederix (Ph.D. UCL): Higgs EFT, New Models and HELAS routines, tt studies
  • MH (Ph.D. UCL): 2HDM, general structure, web interface and cluster management
The "big" picture

Detector simulation

Hadronization

Parton showers

Hard interaction

Pythia, Herwig

MG/ME

PGS, CMS, ATLAS, ...

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Structure Flow Chart

Model

- particles.dat
- interactions.dat
- couplings.f

Calculator

- proc_card
- param_card
- run_card
- pythia_card
- pgs_card

Parton-level events

- MG
- Parton-level events
- Feyn. diags.
- HELAS amplitudes
- plot_card

Reconstructed events

- ME
- Hadron-level events

- Pythia
- Pythia rootfile Plots

- PGS
- PGS rootfile Plots

ROOT

- Parton-level rootfile Plots
Warning...

DO NOT RUN AWAY
It's much less complicated than it seems!!!

Let me show it...
Clusters

http://madgraph.ucl.ac.be : the “official” one (24 dedicated +48 shared CPUs, Condor)

http://madgraph.roma2.infn.it : the Roman one (36 dedicated CPUs, OpenPBS)

http://madgraph.hep.uiuc.edu : the original one (36 dedicated CPUs), still running v3 (will be upgraded in a few days, PBSPro)
New Models: MSSM

Hagiwara, Kaoru, Plehn, Rainwater, Stelzer + Alwall

- CP and R-parity conserving MSSM
- SUSY Les Houches input files – independent of SUSY breaking scheme
- Detailed comparison of cross sections between SMadGraph, Omega and Amegic++ (hep-ph/0512260)
- Input files for the 10 SPS points available
New Models: Generic 2HDM

de Vissher, MH

- Completely general 2HDM, with FCNC and CP violation
- New tree-level calculator with a web interface, TwoHiggsCalc, to generate the param_card needed by MadEvent
- Generic basis or Higgs basis, intensive use of recent basis invariance techniques (e.g. hep-ph/0504050)
- Tested in the SM & MSSM limit
- Sample files for various cases
New Models: Higgs EFT & User Model

- Higgs Effective Theory (Frederix)
  - Effective couplings of Higgs to gluons
  - Also implemented in 2HDM

- User model (de Visscher)
  - General framework for user-defined models
  - User only needs to introduce the new particles, new interactions, new parameters and new couplings. A Perl script takes care of the rest!
  - Already used for a technicolor-like model (Gudnason, Bohr Inst.), for spin 1 and spin 2 heavy resonances (Frederix), heavy top and currently for UED (Alves, UNESP)
Matching ME-PS (Alwall)

- ME+PS matching example
- 1->2 jet rates for W+jets at Tevatron
- Different MG diagrams dominant in different regions of Qpar2(kTdistance of the kTclustering algorithm)
- Clear cut around 10 GeV between 1 and 2 jet final states
- Smooth transition between them shows that matching works
Matching ME-PS (Alwall)

- Transverse momentum of $W$ in $W+jets$ at Tevatron
- MadGraph + parton showers and hadronization of Pythia gives very good description of Tevatron data
And also...

- The new LHE format
- “Universal” XML file format to store parton level event information (hep-ph/0609017)
- MG/ME specific information: the banner is stored as a header (XML comment)

```xml
<init>
  2212 2212 0.70600900900900E+04 0.70600900900900E+04 0 0 0 0 0 0 0 1 0 0.148238400900E+04 0.349100000000E+01 0.14798682338E+00 661
</init>

<event>
  6 661 0.14798682338E+00 0.91188090909090E+02 0.7813608E-02 0.1390000000E+00
  21 -1 0 0 0 561 502 0.000000000000E+00 0.000000000000E+00 0.11338424644E+03 0.11338424644E+03 0.000000000000E+00 0.000000000000E+00 -1.1
  4 -1 0 0 0 562 0 0.000000000000E+00 0.000000000000E+00 -0.32146691772E+02 0.32146691772E+02 0.000000000000E+00 0.000000000000E+00 -1.1
  24 2 1 2 0 0 -0.32718666599E+02 -0.20244311396E+01 0.46352382880E+02 0.9909692539E+02 0.9909692539E+02 0.000000000000E+00 0.000000000000E+00 -1.1
  -11 1 3 3 0 0 -0.17554879259E+02 -0.23683422954E+02 0.6295964966E+02 0.6295964966E+02 0.6295964966E+02 0.6295964966E+02 0.000000000000E+00 0.000000000000E+00 -1.1
  12 1 3 3 0 0 -0.15163787331E+02 -0.2165991915E+02 -0.14697242076E+02 0.29797671566E+02 0.29797671566E+02 0.000000000000E+00 0.000000000000E+00 -1.1
  3 1 1 2 561 0 -0.32718666599E+02 -0.20244311396E+01 0.32885771777E+02 0.46433645671E+02 0.46433645671E+02 0.46433645671E+02 0.000000000000E+00 0.000000000000E+00 -1.1
</event>
```

- The DECAY library allowing the decay of final state particles
- StandAlone version of MadGraph to allow code comparison at the ME level, even for new models
- Easy installation/update procedures for MG/ME servers using CVS, full support for both PBS & Condor clusters
And also...

- BRIDGE: C++ package created by Patrick Meade (Harvard) and Matt Reece (Cornell)
  - Automatic decay widths and BR computations for any particle in any MG model
  - Allows decays of final state unstable particles from LHE event files for any model (current DECAY only for SM)
  - Fully v4 compatible

- MadGraphInterface: developed by Hector Naves Sordo and Maria Forbord Hansen (CERN), now maintained by Dorian Kcira (UCL)
  - Takes the LHE event format as input
  - Part of CMSSW in the GeneratorInterface subsystem
  - Wiki Web page:
    https://twiki.cern.ch/twiki/bin/view/CMS/MadgraphInterface
Work in progress

• Specification of complete decay chains (for models with large number of new particles) w/o computing all diagrams, planned for version 4.2 (J. Alwall, T. Stelzer)

• Interface to the ATLAS software suite (ATLFAST + ATHENA)

• Mathematica based software for extracting fortran algebraic expressions of couplings directly from Lagrangian (C. Duhr)

• Scripts for automatic mass generation (>100000 events samples) and “library” of some standard SM processes (tt~, W+nj, ...)

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Future?

- Other new models (Leptoquark, Top anomalous couplings, LR, ...)
- Full support of spin 2 particles in HELAS
- Automatic support of non-renormalizable interactions with virtual particles techniques
- Tools for easier support of non “accelerator like” collisions (fixed target, neutrinos, ...)
- Model guessing from data (BARD, inverse problem, ...)
- Your desires/ideas/proposals ... ?
Conclusion

- MadGraph/MadEvent 4.1 is available now!
- Key points of its philosophy:
  - **Multi purpose**: new models are now easy to implement, and some of them are already there (MSSM, 2HDM, Higgs EFT, ...)
  - **Complete**: a unique interface from model to detector
  - **Easy input method**: OSOC (one step, one card)
  - **User friendly**: thanks to the complete web interface
  - **Fast**: thanks to the cluster oriented structure
  - **Open**: LHA and LHE compliant, interfaces for Pythia, PGS, ROOT and more soon. CVS interface.