MADGRAPH/MADEVENT - THE NEW WEB GENERATION

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The new web-based version of the automatized process and event generator MadGraph/MadEvent is now available. Recent developments are: New models, notably MSSM, 2HDM and a framework for addition of user-defined models, inclusive sample generation and on-line hadronization and detector simulation. Event generation can be done on-line on any of our clusters.

1. Introduction

As the start of operation for the LHC experiment is drawing closer, it is becoming increasingly important to have efficient and versatile simulation tools, for signals as well as backgrounds. As an example, for processes with new heavy particles which decay in a large number of final-state particles, it might be important to keep full spin correlations in order to make distinctions between different models of new physics. For such processes, the Standard Model background is also complicated due to the number of final state particles with large transverse momenta.

MadGraph/MadEvent[1] is a fully automatized tool for generation of cross sections and unweighted events for processes, both in the Standard Model and for several models of new physics. MadGraph[2] takes as input a process, specified in a simple syntax, and a model definition. It is also possible to specify multi-particle labels, the maximum order in the different couplings (e.g. QCD and QED), and require or exclude intermediate s-channel particles. MadGraph produces all possible Feynman diagrams for this process, as well as its matrix element expression in the form of a Fortran subroutine with calls to the helicity amplitude library HELAS[3]. MadEvent[4] then performs the phase space integration (including any spec-

ified cuts) and produces weighted and unweighted events for the process, using a technique dubbed "Single-diagram-enhanced multichannel integration", which gives high unweighting efficiencies also for multi-particle final states. This technique has the additional advantage that it is very easily parallelized to run on multi-processor clusters. Events are output to a text file following the Les Houches Accord for event generation[5], and interfaces to Pythia[6] and Herwig[7] allows for the addition of parton showering and hadronization.

Recently, MadGraph/MadEvent has been made even more accessible with the introduction of several dedicated computer clusters around the world, where users may run process generation and event generation over the Internet, using a simple but powerful web interface. It is also possible to download the source code to compile and run locally.

2. Recent and future developments

2.1. *New Models*

The original MadEvent only included the Standard Model (with and without non-diagonal CKM matrix). In the new version, several models have been added (the people responsible for the implementations in parentheses): The minimal supersymmetric extension of the Standard Model (MSSM) (J. Alwall, UCL), the general two Higgs doublet model (2HDM) (M. Herquet and S. de Visscher, UCL) and Higgs effective couplings to gluons (HiggsEFT) (R. Frederix, UCL). There is also a framework for the addition of new models which allows for automatic generation of all necessary MadEvent files from the MadGraph files determining the particle content and interactions of the new model (S. de Visscher).

MSSM: The implementation of supersymmetry into MadGraph was made by T. Plehn et al.[8], and is restricted to the minimal supersymmetric model conserving R-parity, without CP-violating phases and with diagonal CKM and MNS matrices. Higgs Yukawa couplings as well as mixing between right- and left-handed sfermions are implemented only for the third generation. However, no specific supersymmetry breaking scheme is assumed, so the spectrum and couplings of the supersymmetric particles can be produced with any spectrum generator regardless of the assumptions going into its calculations. The spectrum and couplings of the particles are read through SUSY Les Houches Accord (SLHA) files[9]. To ensure the correctness of the implementation, a detailed comparison of some 500 different production processes has been made between several unrelated automatized

event generators[10].

2HDM: The implementation of the general 2HDM uses the most general two Higgs doublet potential, including CP violating phases and arbitrary sharing of Yukawa couplings to fermions between the two Higgs doublets. It is being tested by comparisons in the Standard Model and MSSM limits. An independent web-based calculation tool, written by M. Herquet, computes the Higgs boson mass spectrum, mixing matrices and decay widths from the parameters of the Lagrangian and provides output in a SLHA-like file format, which is then used as input to MadEvent. This tool can also convert input between the general basis and the Higgs basis for the Higgs potential.

2.2. *Further developments*

Other new developments include the possibility to generate several different processes in the same run, the automatic inclusion of parton showering, hadronization and detector simulation in the web based generation, and a new structure of input files.

Inclusive sample generation: It is now possible to specify several different processes in the same run, such as inclusive multi-jet samples or the generation of signal and background events in the same run. The different processes are then generated in the correct proportions as given by their cross sections after cuts.

Hadronization and detector simulation: In the web based version the user can choose to run the events generated by MadEvent through Pythia[6] and then through PGS[11]. Pythia handles parton showering, decay of undecayed resonances and hadronization, while PGS is a fast detector simulation package with the possibility to simulate typical detectors at Tevatron and the LHC.

New cards: The input files for the new version of MadGraph/MadEvent have been changed to better reflect the different aspects of the generation: proc_card.dat specifies the process to be produced, which model to use and multi-particle labels; param_card.dat specifies the model parameters such as masses and couplings; run_card.dat specifies the type of collider, collider energy, parton distributions and cuts.

There are also cards read by Pythia and PGS (pythia_card.dat and pgs_card.dat) to specify their behavior. All these cards can be generated on the Internet with user-friendly web forms, and they can all be reused in new runs independently of each other.

2.3. *Work in progress*

With the possibility to generate inclusive multi-jet samples, there is also a need to match these to jet production through parton showering in order not to get double counting of jets. In recent years several new methods have been proposed for this matching, notably the CKKW[12] and MLM[13] methods. Work is in progress to implement an automatic matching between Pythia parton showers and hard jets from MadEvent.

There is also ongoing work to extend MadGraph to allow for the specification of complete decay chains, to facilitate studies of e.g. supersymmetric processes.

3. Final words

MadGraph/MadEvent 4.0 is now out and operational. Please try it out on one of our clusters (registration is quick and free!)
`http://madgraph.phys.ucl.ac.be/`
`http://madgraph.roma2.infn.it/`
`http://madgraph.hep.uiuc.edu/`

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