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
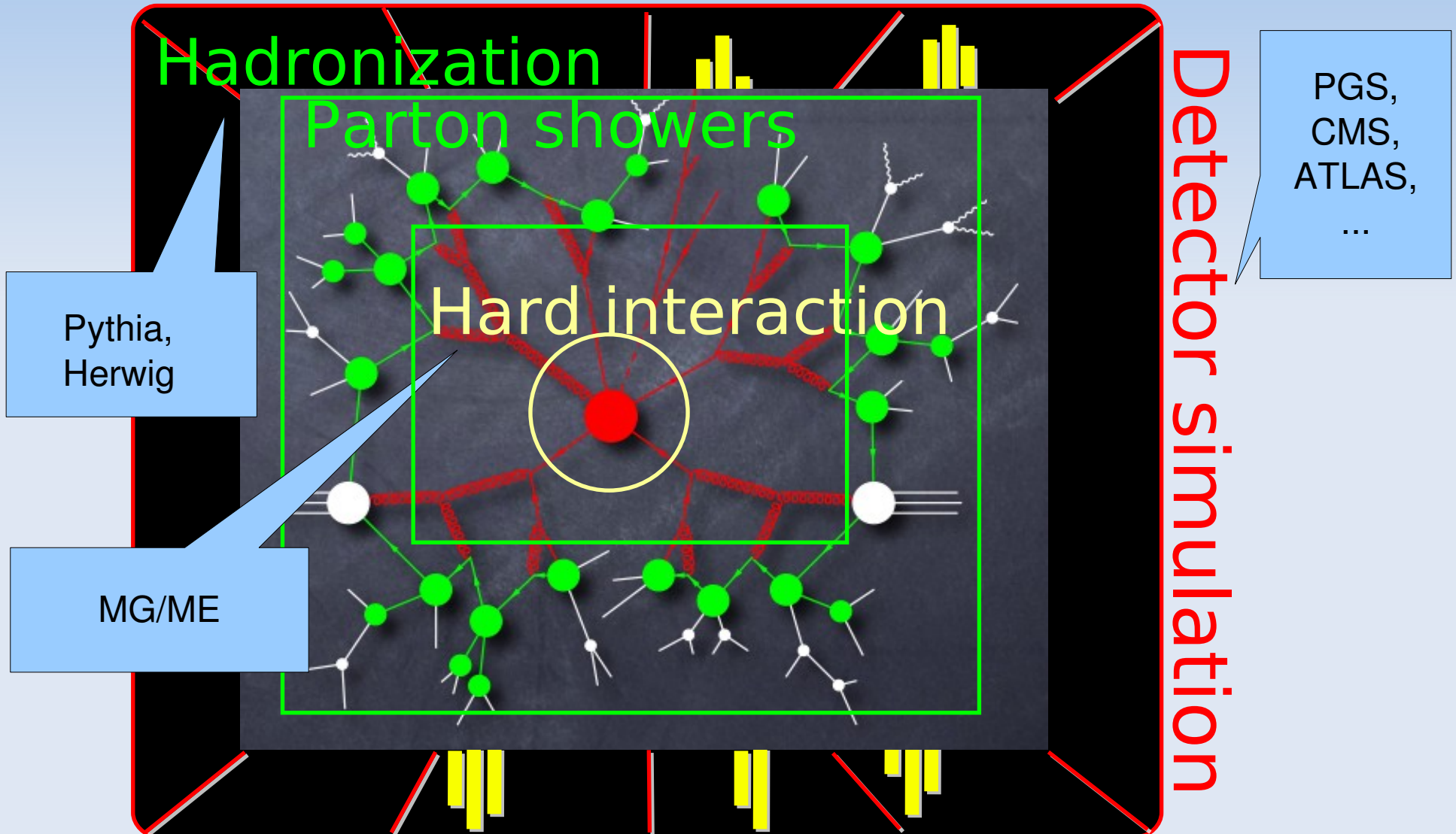
MG/ME Who's Who

- 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
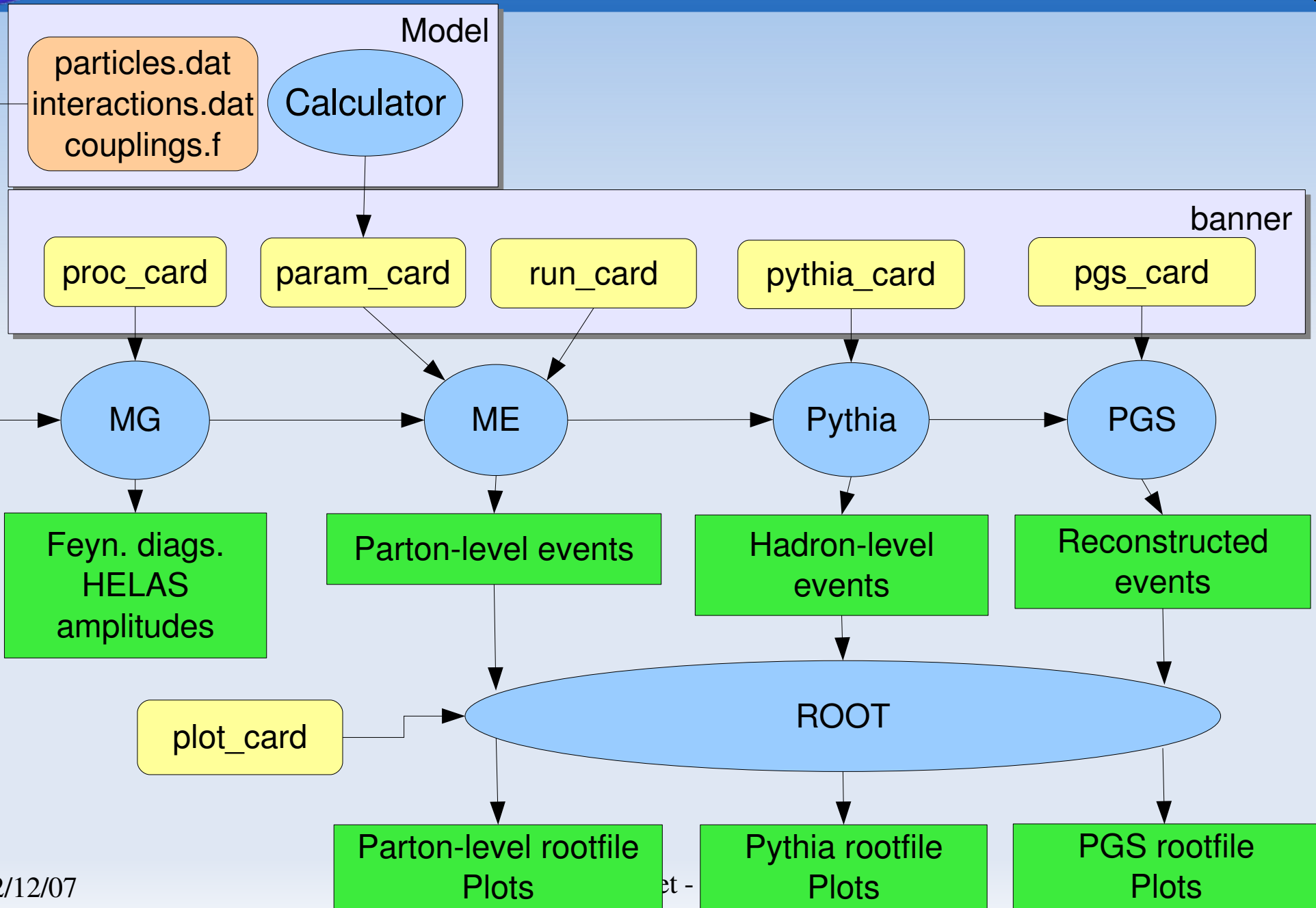 - *MH* (Ph.D. UCL): 2HDM, general structure, web interface and cluster management

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)

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
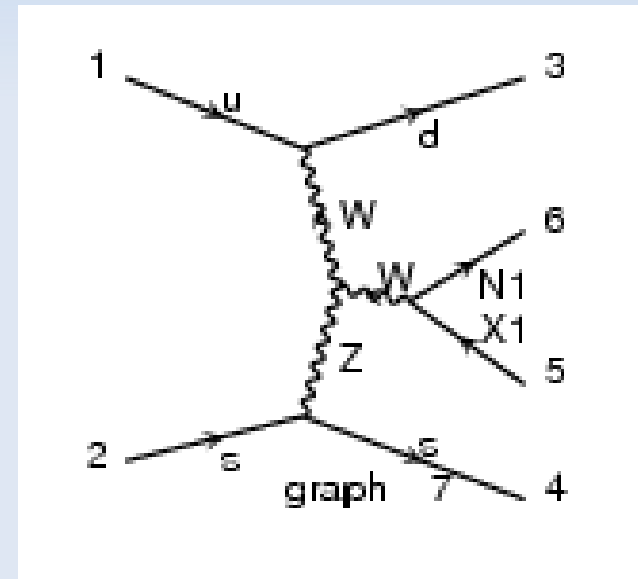
de Vissher, MH

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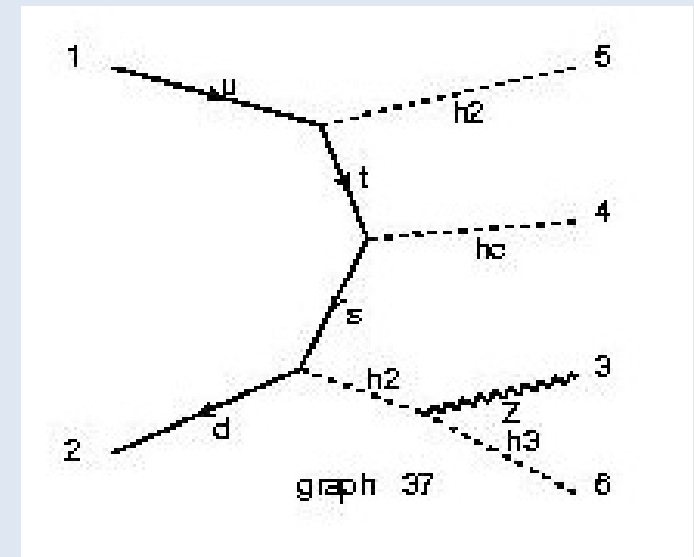
- Higgs Effective Theory (Frederix)
  - Effective couplings of Higgs to gluons
  - Also implemented in 2HDM

- 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)
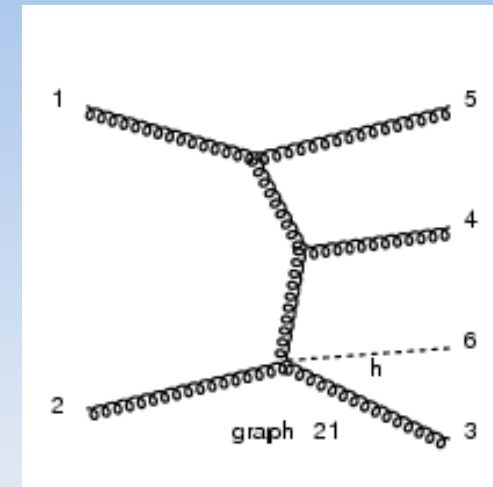
- ME+PS matching example

- 1->2 jet rates for W+jets at Tevatron

- Different MG diagrams dominant in different regions of Qpar2(kTdistance of the kTclustering altorithm)

- Clear cut around 10 GeV between 1 and 2 jet final states

- Smooth transition between them shows that matching works

Diff. 1->2 jet rate (parton level) in W + jets at Tevatron by MadEvent/Pythia

Legend:
- Sum of contributions
- 0-jet sample
- 1-jet
- 2-jet
- 3-jet
- 4-jet

Matching ME-PS (Alwall)
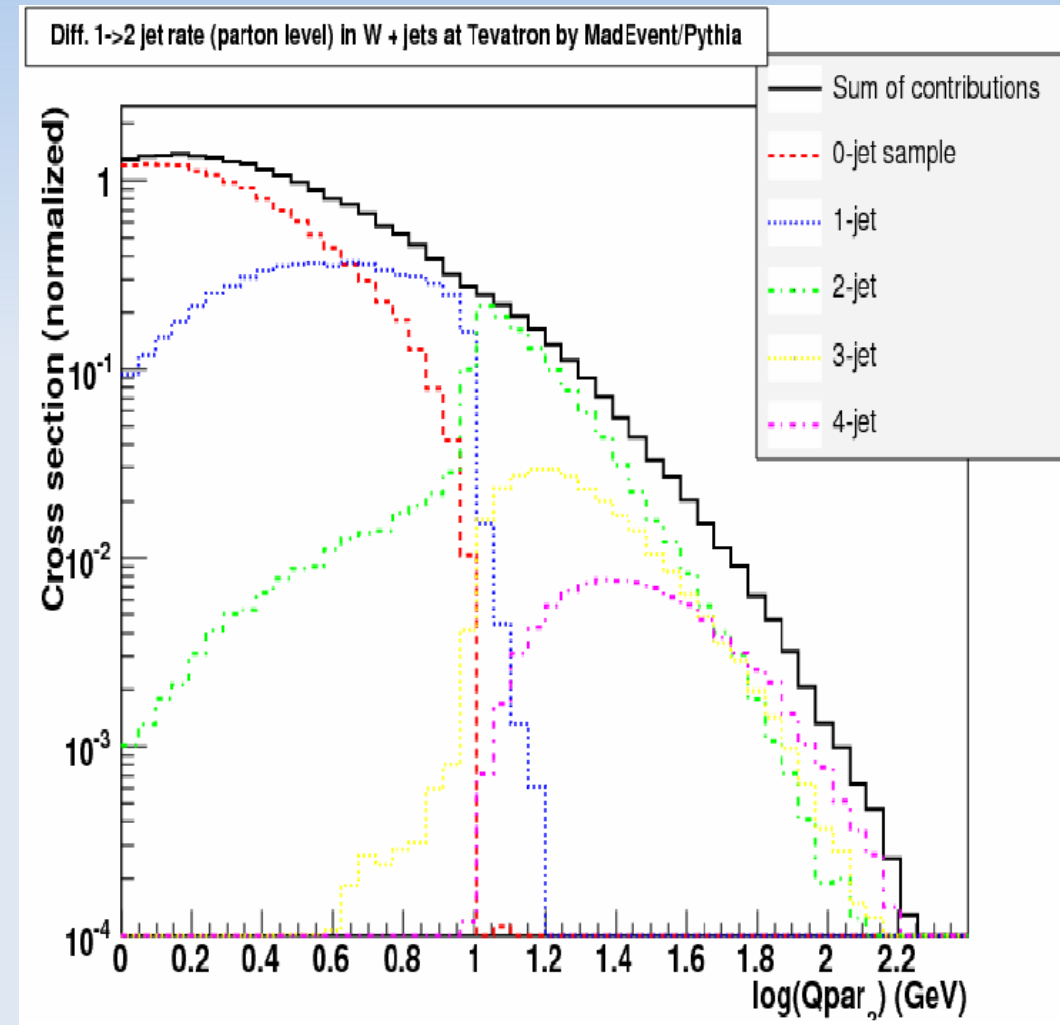
- Transverse momentum of W in W+jets at Tevatron

- MadGraph + parton showers and hadronization of Pythia gives very good description of Tevatron data

Pt of the W in W + jets at Tevatron by MadEvent/Pythia

Legend:
- Sum of contributions
- 0-jet sample
- 1-jet
- 2-jet
- 3-jet
- 4-jet
- D0 run 1 data
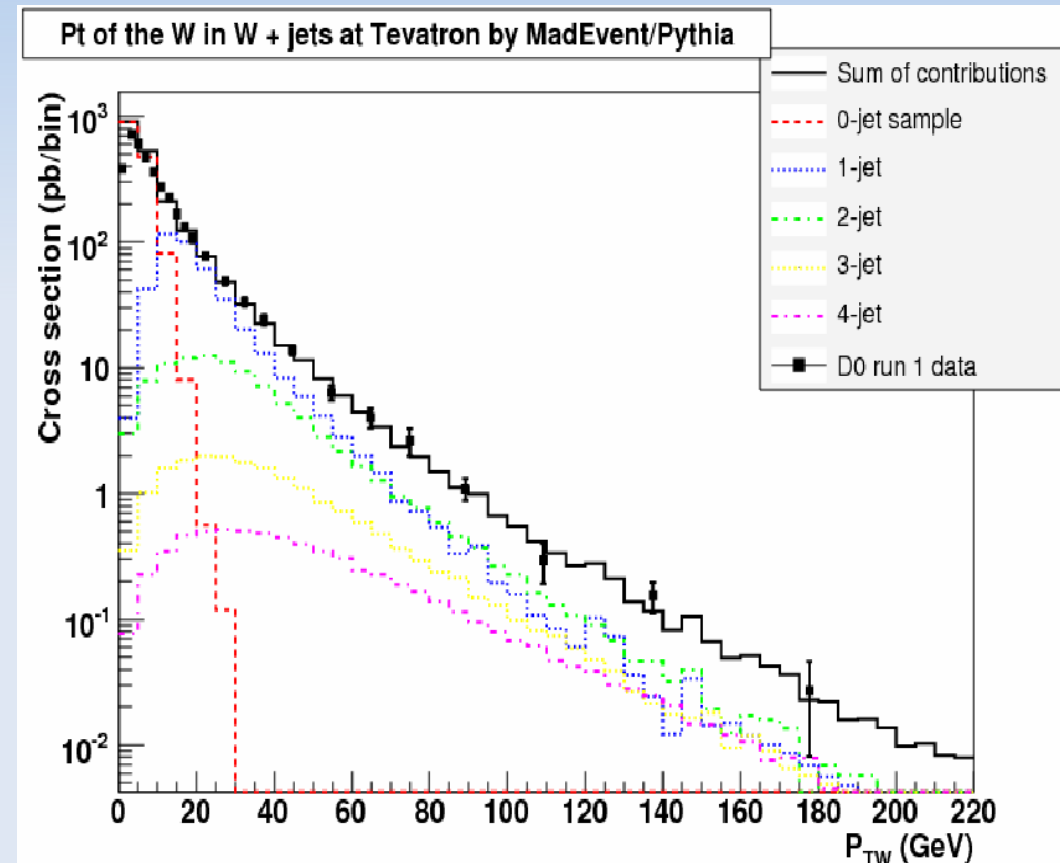
And also...

- 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)

```
<init>
  2212  2212  0.70000000000E+04  0.70000000000E+04 0 0 10042 10042 3 1
  0.14823840098E+04  0.34010000000E+01  0.14798682338E+00 661
</init>
<event>
 6 661  0.1479868E+00  0.9118800E+02  0.7818608E-02  0.1300000E+00
       21   -1    0    0  501  502  0.00000000000E+00  0.00000000000E+00  0.11338424644E+03  0.11338424644E+03  0.00000000000E+00 0. -1.
        4   -1    0    0  502    0  0.00000000000E+00  0.00000000000E+00 -0.32146091772E+02  0.32146091772E+02  0.00000000000E+00 0. -1.
       24    2    1    2    0    0 -0.32718666590E+02 -0.20244311396E+01  0.48352382890E+02  0.99096692539E+02  0.80047436412E+02 0.  0.
      -11    1    3    3    0    0 -0.17554879259E+02 -0.23083422954E+02  0.62959624966E+02  0.69317620970E+02  0.00000000000E+00 0.  1.
       12    1    3    3    0    0 -0.15163787331E+02  0.21058991815E+02 -0.14607242076E+02  0.29779071569E+02  0.00000000000E+00 0. -1.
        3    1    1    2  501    0  0.32718666590E+02  0.20244311396E+01  0.32885771777E+02  0.46433645671E+02  0.00000000000E+00 0. -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, ...)

- 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 … ?**

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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.