



# MadGraph/MadEvent 4.0

## The New Web Generation

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MC4LHC, CERN, 17 July 2006

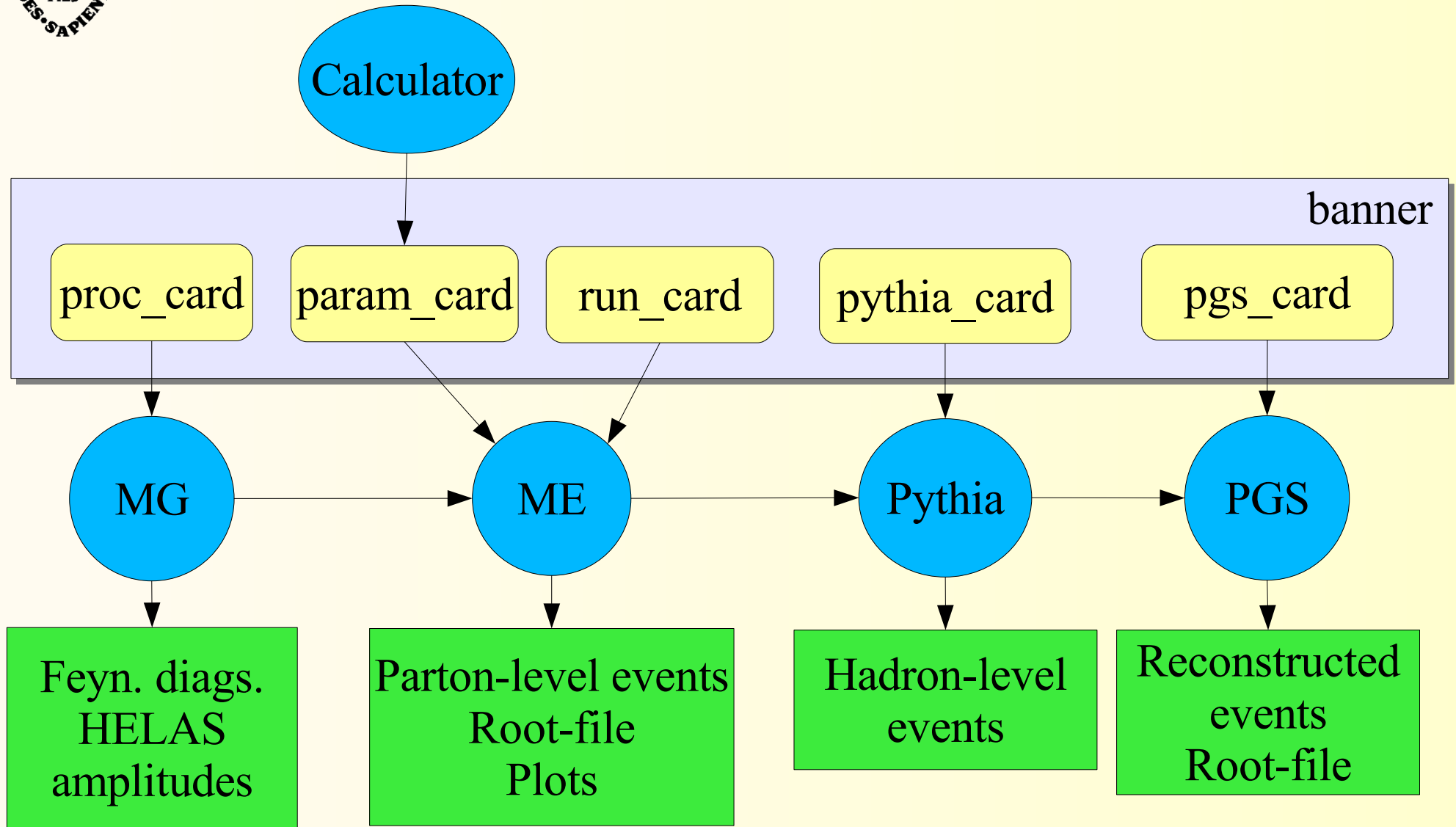


# What is new in MG/ME 4?

- Web-oriented, modular software structure
- New models
  - SUSY, 2HDM and Higgs EFT
  - Framework for easy user model implementation
- Multiple/inclusive processes in single run
- Pythia and PGS packages for complete event simulation on-line
- Two new clusters (Rome and UCL)
- Local cluster installation/updating now easy using CVS



# MG/ME 4 generation structure





# MG/ME new structure



- Whole chain on web or downloaded and run locally
- Cards filled on the web or uploaded (reusable)
- Model parameters prepared with external calculator
- Modular structure – easy to interface to other applications / add new functionality
- Whole structure maintained via CVS
- Open source philosophy – contributions welcome!

# Calculators



- SLHA-like output format (param\_card)
- Can be used by other event generators
- MSSM
  - Takes SLHA files from any SUSY spectrum generator
  - Calculates dependent SM parameters and decay widths
- 2HDM
  - Enter potential parameters and Yukawa couplings
  - Choice between Higgs basis and general basis
  - Calculates masses, mixings, couplings and decay widths

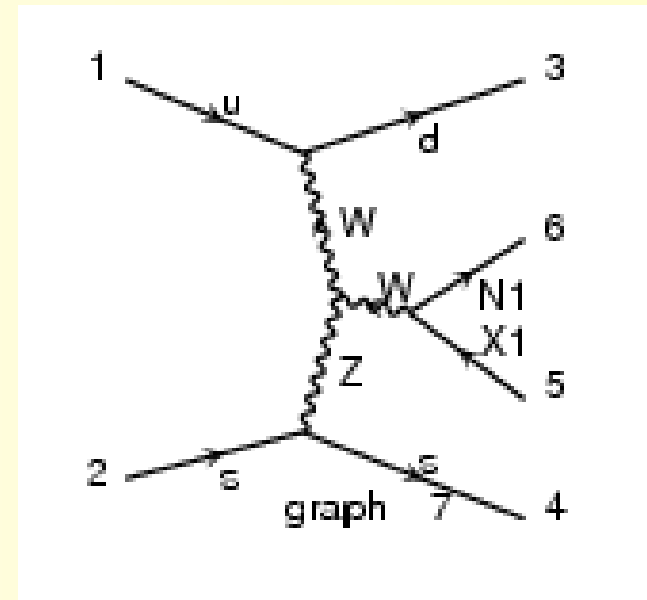


# New models: MSSM



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

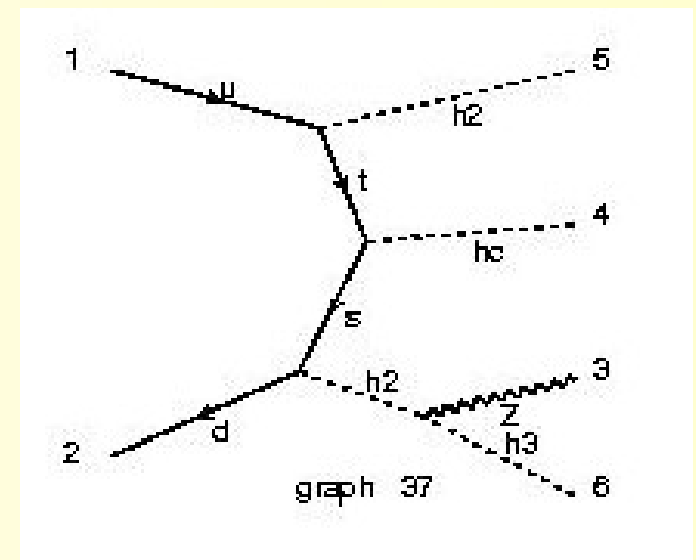




# General 2HDM

de Vissher, Herquet, Ovyn

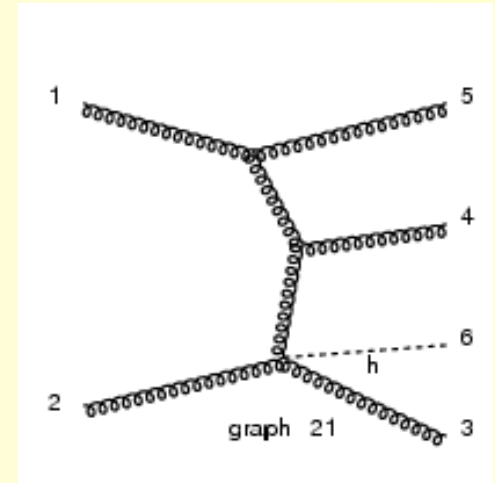
- Completely general 2HDM, with FCNC and CP violation
- New tree-level calculator with a web interface, TwoHiggsCalc, to generate the param\_card needed by MadEvent
- Generic basis or Higgs basis, intensive use of recent basis invariance techniques (e.g. hep-ph/0504050)
- Tested in the SM & MSSM limit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



# Higgs EFT & User model



- Higgs Effective Theory (**Frederix**)
  - Effective couplings of Higgs to gluons
- 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!
  - Currently used for a technicolor-like model (**Gudnason**)







# Work in progress



- More models: Technicolor, UED (**Alves**), ...
- Specification of complete decay chains
  - Allows for large number of final state particles
  - Keeps full spin correlations
- Automatic matching of matrix elements and parton showers (**Alwall - Höche**)
  - Using CKKW and MLM schemes
- Automatic width calculator for new models
- Matrix element techniques for signal selection

# Conclusion



- MadGraph/MadEvent 4.0 is available now!
- Key points of its philosophy:
  - **Multi purpose** : signal + background with same tool; new models easy to implement, and several already there (MSSM, 2HDM, Higgs EFT, ...)
  - **Complete** : from model to detector in one run
  - **User friendly** : on-line or downloaded
  - **Fast** : thanks to parallelized, cluster oriented generation
  - **Portable** : easily install on new clusters from CVS
  - **Open** : LHA compliant, interfaces for Pythia, PGS, Root, Herwig and more soon



# Try it out



- Clusters found at:
  - UCL: <http://madgraph.phys.ucl.ac.be/>
  - Rome: <http://madgraph.roma2.infn.it/>
  - UIUC: <http://madgraph.hep.uiuc.edu/> (still version 3)
- Registration for on-line process generation is quick and automatic
- To do on-line event generation – send us a mail!
- We are continually improving MadGraph/MadEvent, grateful for all feedback!



# Backup slides





# The cards

- The proc\_card:

```
pp > W+jjj  
QCD=3  
QED=1  
sm
```

- Defines the process(es), order in couplings and model.

- The param\_card:

```
Block MASS  
4 1.400000000E+00
```

- Defines the model parameters (masses, widths and couplings) in SUSY Les Houches-like format

- The run\_card:

```
1 = lpp1 ! beam 1 type  
1 = lpp2 ! beam 2 type  
7000 = ebeam1 ! beam 1 energy  
7000 = ebeam2 ! beam 2 energy
```

- Defines the collider, cuts, parton densities and scales

- The pythia\_card and pgs\_card determine the operation of Pythia and PGS.

# 2HDM Calculator



Higgs Basis ([more info](#))

$$V = \mu_1 H_1^\dagger H_1 + \mu_2 H_2^\dagger H_2 - (\mu_3 H_1^\dagger H_2 + \text{h.c.})$$

$$+ \lambda_1 (H_1^\dagger H_1)^2 + \lambda_2 (H_2^\dagger H_2)^2$$

$$+ \lambda_3 (H_1^\dagger H_1) (H_2^\dagger H_2) + \lambda_4 (H_1^\dagger H_2) (H_2^\dagger H_1)$$

$$+ \left[ (\lambda_5 H_1^\dagger H_2 + \lambda_6 H_1^\dagger H_1 + \lambda_7 H_2^\dagger H_2) (H_1^\dagger H_2) + \text{h.c.} \right]$$

lambda1	1
lambda2	1
lambda3	1
lambda4	0
lambda5	0
Norm of lambda6	0
Norm of lambda7	0
Phase of lambda6	0
Phase of lambda7	0
Mass of Charged Higgs (GeV)	300

Generic Basis ([more info](#))

$$V = \mu_1 \phi_1^\dagger \phi_1 + \mu_2 \phi_2^\dagger \phi_2 - (\mu_3 \phi_1^\dagger \phi_2 + \text{h.c.})$$

$$+ \frac{1}{2} \lambda_1 (\phi_1^\dagger \phi_1)^2 + \frac{1}{2} \lambda_2 (\phi_2^\dagger \phi_2)^2$$

$$+ \lambda_3 (\phi_1^\dagger \phi_1) (\phi_2^\dagger \phi_2) + \lambda_4 (\phi_1^\dagger \phi_2) (\phi_2^\dagger \phi_1)$$

$$+ \left[ \left( \frac{1}{2} \lambda_5 \phi_1^\dagger \phi_2 + \lambda_6 \phi_1^\dagger \phi_1 + \lambda_7 \phi_2^\dagger \phi_2 \right) (\phi_1^\dagger \phi_2) + \text{h.c.} \right]$$

Tan(beta)=v2/v1	1
Phase of v2	0
Norm of mu3	0
lambda1	1
lambda2	1
lambda3	1
lambda4	0
Norm of lambda5	0
Norm of lambda6	0
Norm of lambda7	0
Phase of lambda5	0
Phase of lambda6	0
Phase of lambda7	0

Yukawa parameters

Higgs basis ([more info](#))

$$\mathcal{L}_Y = \frac{\overline{Q}_L \sqrt{2}}{v} \left[ (M_d H_1 + Y_d H_2) d_R + (M_u \tilde{H}_1 + Y_u \tilde{H}_2) u_R \right]$$

$$+ \frac{\overline{E}_L \sqrt{2}}{v} [(M_e H_1 + Y_e H_2) e_R]$$

Generic Basis ([more info](#))

$$\mathcal{L}_Y = \frac{\overline{Q}_L \sqrt{2}}{v} \left[ (\Delta_d \phi_1 + \Gamma_d \phi_2) d_R + (\Delta_u \tilde{\phi}_1 + \Gamma_u \tilde{\phi}_2) u_R \right]$$

$$+ \frac{\overline{E}_L \sqrt{2}}{v} [(\Delta_e \phi_1 + \Gamma_e \phi_2) e_R]$$


Yukawa couplings to the second Higgs doublet of the down type quarks (norm and phase)

Y1D/G1D	0	0	Y1S/G1S	0	0	Y1B/G1B	0	0
Y2D/G2D	0	0	Y2S/G2S	0	0	Y2B/G2B	0	0
Y3D/G3D	0	0	Y3S/G3S	0	0	Y3B/G3B	0	0

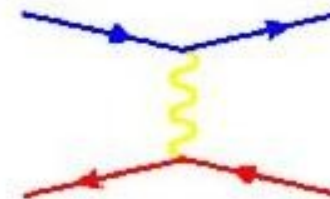
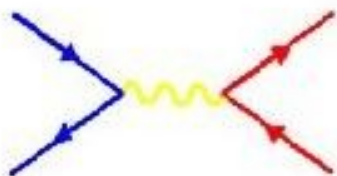
# Results of the web run



UCL UTUC Fermi

MadGraph Version 4.0 at 

by Fabio Maltoni, Tim Stelzer  
and the CP3 Development team



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## Results for $pp \rightarrow tt\bar{j}$ in the sm

### Available Results

Links	Events	Tag	Run	Collider	Cross section (pb)	Events
<a href="#">results</a> <a href="#">plots</a> <a href="#">banner</a>	<a href="#">parton-level rootfile</a> <a href="#">hadron-level (Pythia)</a> <a href="#">reconstructed objects (PGS) rootfile (everything)</a>	fermi	run1	pp 7000 x 7000 GeV	.74061E+03	9947

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# Particles and interactions



```
#Name anti_Name Spin Linetype Mass Width Color Label Model
#xxx xxxx SFV WSDC str str STO str PDG code

#
# Quarks
#
d d~ F S ZERO ZERO T d 1
u u~ F S ZERO ZERO T u 2
s s~ F S ZERO ZERO T s 3
c c~ F S ZERO ZERO T c 4
b b~ F S BMASS ZERO T b 5
t t~ F S TMASS TWIDTH T t 6
```

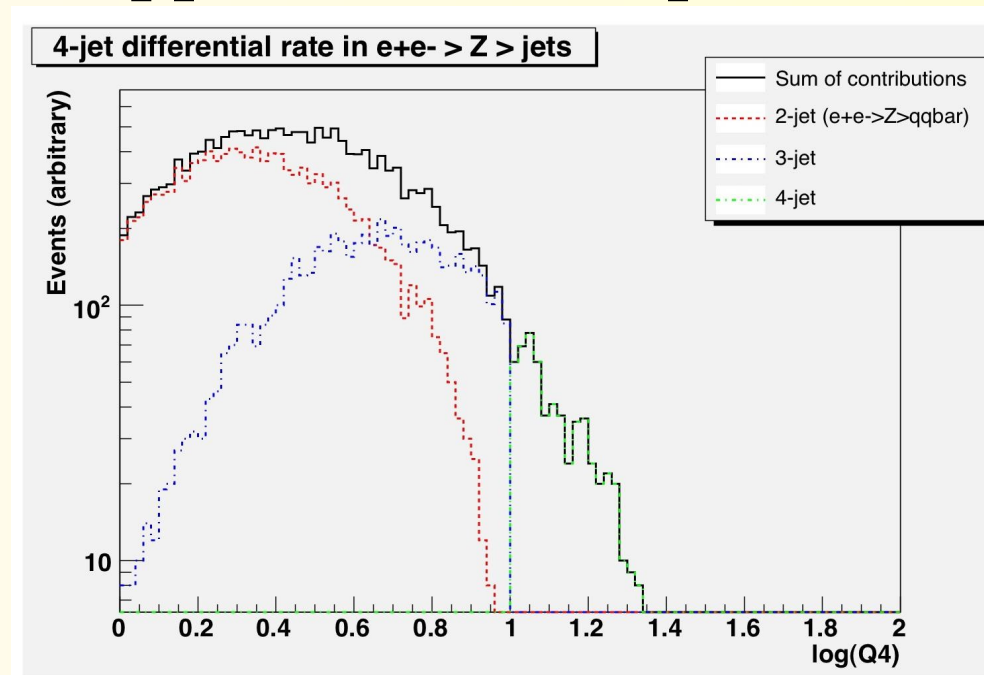
```
#
# QCD interactions
#
d d g GG QCD
u u g GG QCD
s s g GG QCD
c c g GG QCD
b b g GG QCD
t t g GG QCD

g g g G QCD
```



# Matching of ME and PS

- MLM-like with Pythia  $p_T$  - ordered showers (**Alwall**)  
(Sudakov suppression from parton showers)



- CKKW-like with Sherpa showers (analytic Sudakovs) (**Höche - Alwall**)