MadGraph 5

The New MadGraph Generation

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MADGRAPH 4

MadGraph 4

Diagram

- Diagram Generation
- Amplitude (via Helas Routine)
- Link to Set of Package (MadDipole, MadFKS, MadWeight, ...)

MADGRAPH 4

MadGraph 4

Diagram

MadEvent

Partonic Events

- Cross section
- distribution
- Events

MADGRAPH 4

MadGraph 4

Diagram

MadEvent

Partonic Events

- Cross section
- distribution
- Events
- Quarkonium
- Matching

MADGRAPH 4

MadGraph 4 — Diagram

MadEvent — Partonic Events

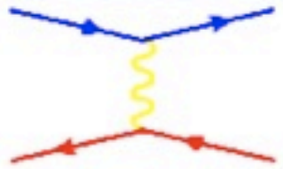
Pythia — Hadronization

PGS/Delphes — Detector

MadGraph Version 4

UCL UIUC Fermi

by the MG/ME Development team



Generate Process | Register | Tools | My Database | Cluster Status | Downloads (needs registration) | Wiki/Docs | Admin

Code can be generated either by:

I. Fill the form:

Model: SM — Model descriptions

Input Process: — Examples

Max QCD Order: 99

Max QED Order: 99

p and j definitions: p=j=d u s c d~ u~ s~ c~ g

sum over leptons: l+ = e+, mu+ ; l- = e-, mu- ; vl = ve, vm ; vl~ = ve~, vm~

Submit

MADGRAPH 4

FeynRules — Model

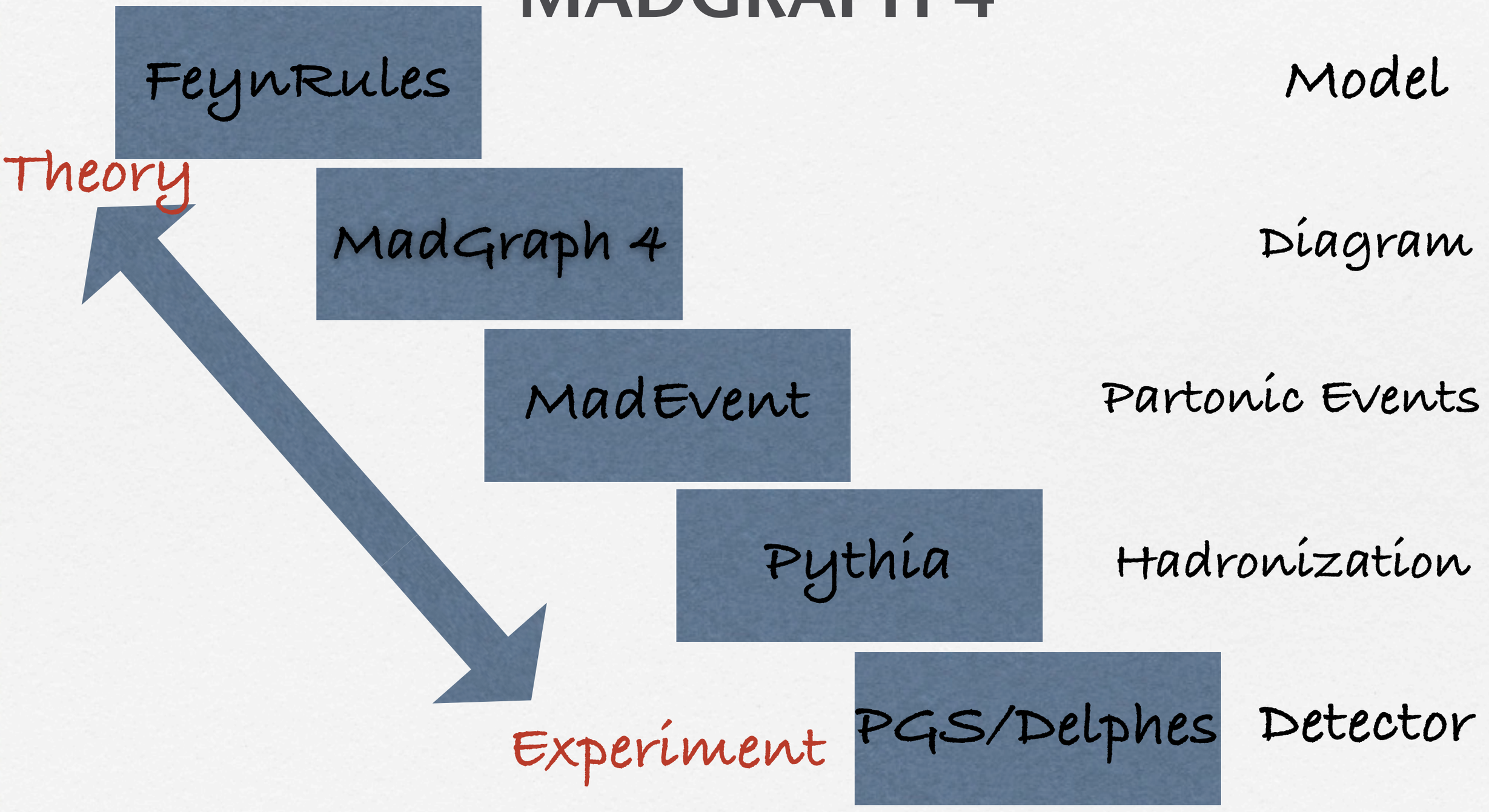
MadGraph 4 — Diagram

MadEvent — Partonic Events

Pythia — Hadronization

PGS/Delphes — Detector

MADGRAPH 4


FeynRules
Model
Theory
MadGraph 4
Diagram
MadEvent
Partonic Events
Pythia
Hadronization
Experiment
PGS/Delphes
Detector

MADGRAPH 4

FeynRules — Model

MADGRAPH 5 — Diagram

MadEvent — Partonic Events

Pythia — Hadronization

PGS/Delphes — Detector

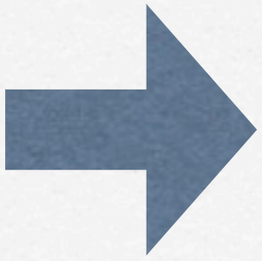
WHY CHANGE?

WHY CHANGE?

~~Harder~~

WHY CHANGE?

- MG4 is in fortran 77
  - Not Object Oriented
  - predefine memory use
- MG4 is an old code (1994)
  - New Implementations are hard



Time For a new Start

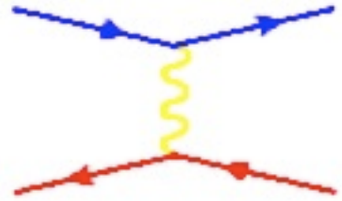
~~Harder~~

MG5 and Python

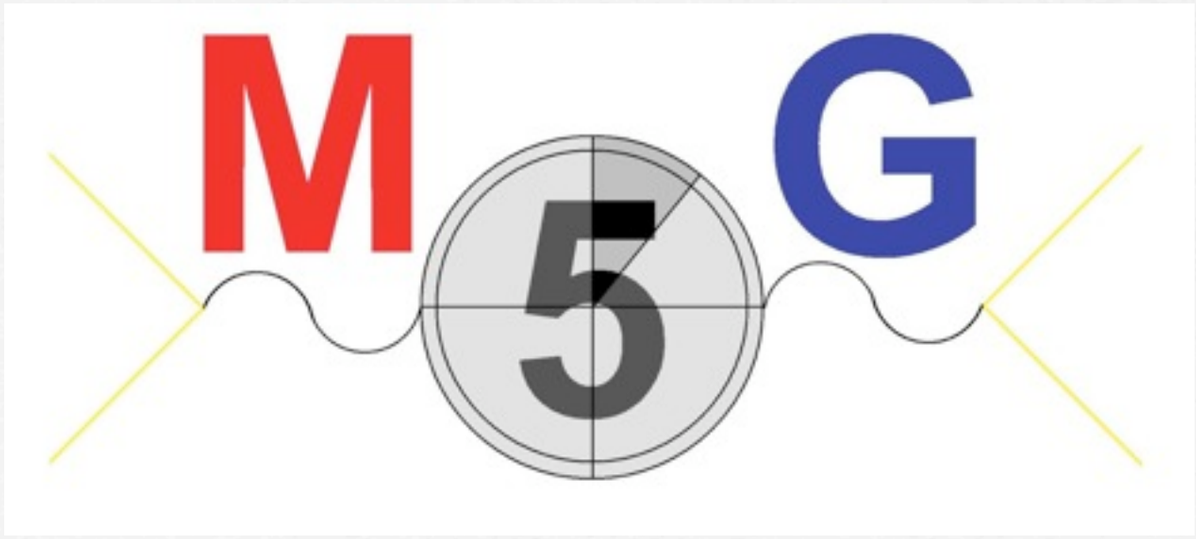
MadGraph Version 4

UCL UIUC Fermi

by the MG/ME Development team



python™



Better

Check List

Leading order matrix element generation	≤ 8 FS, <10000 diag Max. W+4 jet/$t\bar{t}$+3 jet
BSM, any renormalizable model	Yes
Decay Chains	Max 8 FS, slow
Color structures	Singlet/triplet/octet
Extended color structures (6, 27, ε^{ijk})	No
Effective theories (>4-particle vx)	No
Recursion relations for multijet generation	No
NLO real corrections	Yes
NLO loop calculations	In progress
Output in any language/format	Only Fortran

Stronger

Development

- Development starts at MadGraph 2009
- Modular Program Structure
- Modern Programming Technique
  "Extreme Programming"
- Complete test suite including extensive module/function testing

Better

Check List

Leading order matrix element generation	No limitations except time W+5 jets/$t\bar{t}$+4 jets realistic
BSM, any renormalizable model	Yes
Decay Chains	No limitations, fast
Color structures	No limitations
Extended color structures (6, 27, ε^{ijk})	Available (not yet tested)
Effective theories (>4-particle vx)	Yes, no limitations
Recursion relations for multijets	To be implemented
NLO real corrections	To be implemented
NLO loop calculations	To be implemented
Output in any language/format	No limitations, Fortran (MG/ME 4) available

Stronger

Status

Beta 0.4.2 currently available

https://launchpad.net/madgraph5

- 99 % retro-compatible with v4 input
- Complete Majorana treatment
- Complete MadGraph StandAlone / Madevent Output
- Extensively tested against MG4
- Shell mode with help and more options

Faster

Speed Benchmark

Process	MG4	MG5	Definitions	Subprocs (after combine)	Diagrams	Comments
pp > jjj	29.02 s	54.38 s	p, j=u/u~/c/c~/d/d~/s/s~/g	34	307	
pp > jj l+l-	341 s (5:41 min)	258 s (4:18 min)	p, j=u/u~/c/c~/d/d~/s/s~/g l+-=e+-/mu+-/ta+-	108	1216	
pp > jjj e+e-	2444 s (40:44 min)	993 s (16:33 min)	p, j=u/u~/c/c~/d/d~/s/s~b/b~/g	141	9012	
uu~>e+e-e+e-e+e-	772 s (12:52 min)	175 s (2:55 min)		1	3474	MG4: 3194 wavefunctions MG5: 301 wavefunctions
gg > ggggg	2788 s (46:28 min)	1049 s (17:29 min)		1	7245	MadGraph standalone output MG4: 3745 wavefunctions MG5: 898 wavefunctions
pp > jj (W+ > l+vl)	146 s (2:26 min)	70 s (1:10 min)	p, j=u/u~/c/c~/d/d~/s/s~/g l+=e+/mu+/ta+, vl=ve/vm/vt	82	304	
pp > t t~ with full decays	5640 s (1:34 h)	22.0 s	p=u/u~/c/c~/d/d~/s/s~/g W+/W->du/sc/eve/muvm/tavt	27	45	MG4: 12 proc defs MG5: single proc def
pp>sq sq	222 s (3:42 min)	286 s (4:46 min)	p=u/u~/c/c~/d/d~/s/s~/g sq=go/ul/ur/cl/cr/dl/dr/sl/sr+conj	313	475	
gg>(go>u(ul~>u~(n2>Zn1)))(go>ud~x1-)	383 s (7:23 min)	5.2 s		1	6	7 FS decay chain, single diagram
gg>(go>uu~n1)(go>uu~n1)	70 s	5.5 s		1	48	6 FS decay chain, mult.diag.
pp>(go>jjn1)(go>jjn1)	3 h - >>1 year	551 s (9:11 min)	p, j=u/u~/c/c~/d/d~/s/s~/g	144	11008	

Faster

Speed Benchmark

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uu~>e+e-e+e-e+e-	772 s (12:52 min)	175 s (2:55 min)		1	3474	
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pp > tt~ + decays	1:34 h	22 s	p=u/u~/c/c~/d/d~/s/s~/g W+/W->du/sc/eve/muvm/tavt	27	45	12 proc defs single proc def
pp>sq sq	222 s (3:42 min)	286 s (4:46 min)	p=u/u~/c/c~/d/d~/s/s~/g sq=go/ul/ur/cl/cr/dl/dr/sl/sr+conj	313	475	
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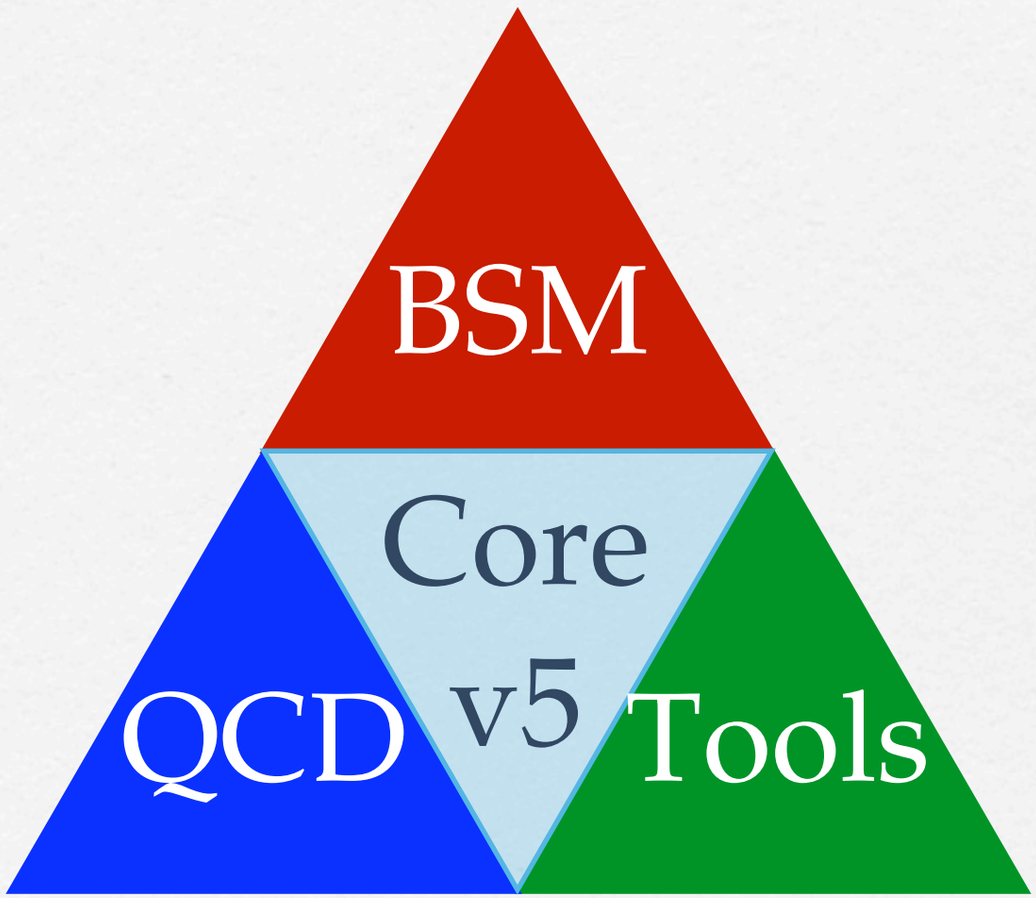
gg>(go>uu~n1)(go>uu~n1)	70 s	5.5 s		1	48	6 FS decay chain, mult.diag.
pp > (go>jjx^0)(go>jjx^0)	>> 1 year	9 min	p, j=u/u~/c/c~/d/d~/s/s~/g	144	11008	

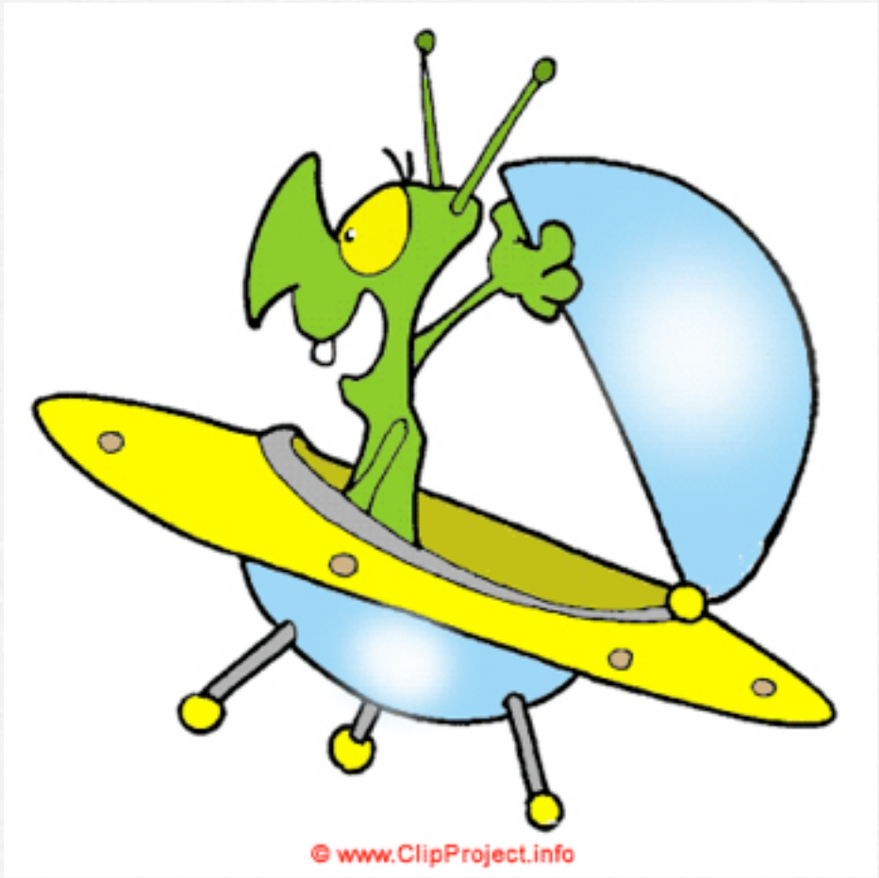
MG4: 3194 wfs
MG5: 301 wfs

~ 2.5 times faster evaluation for produced matrix elements

Development



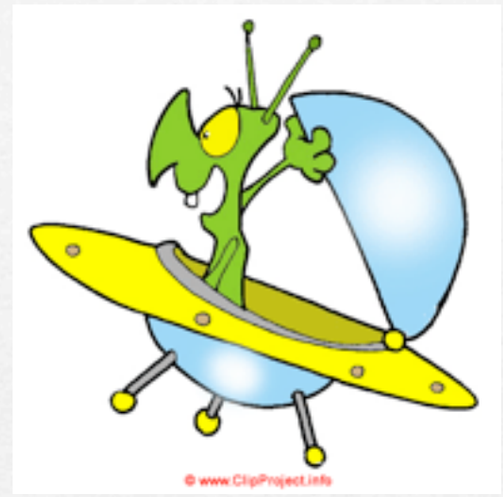
BSM: UFO



UFO = Universal FeynRules Output

BSM: UFO

- New FeynRules output including color and lorentz structures. [Duhr et al]



UFO = Universal FeynRules Output

BSM: UFO AND ALOHA

- New FeynRules output including color and lorentz structures.
  [Duhr et al]

UFO = Universal FeynRules Output

- Automatic Helas Amplitude Generation for any new model (including effective theory)
  [P. de Aquino, W. Link, OM]

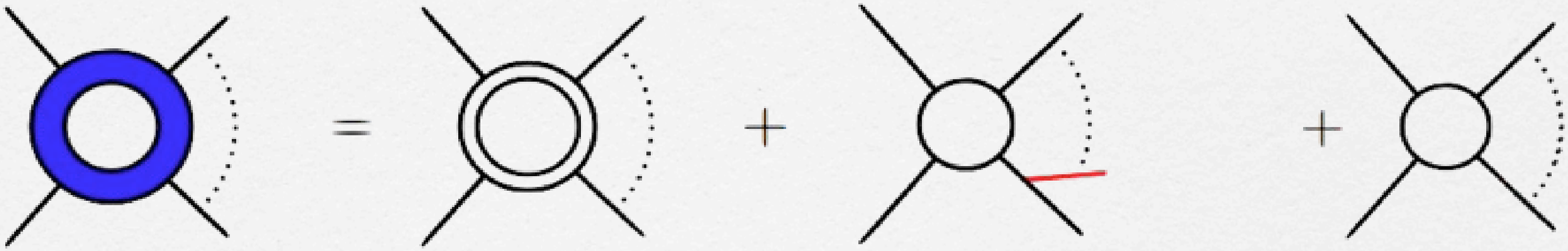
ALOHA = Automatic Language-independent Output of Helicity Amplitudes

Multijets

- For multijet generation (≳ 4 jets), Feynman diagram formalism expensive (factorial growth)
- Helicity amplitude optimization (in MG4/5) reduces run time by factor ~ 10 for complex processes
- Recursion relations (such as Berends-Giele) can reduce run time by additional orders of magnitude
- MG5 perfect framework for implementation and development
- Work started with exciting prospects in near future!

MADGRAPH NLO

NLO Virtual Real Born



$$\sigma^{\mathrm{NLO}} = \int_m d^{(d)}\sigma^V + \int_{m+1} d^{(d)}\sigma^R + \int_m d^{(4)}\sigma^B$$

MADGRAPH: NLO

- Real:
  - MadDipole (TH) MadFKS (TH+PH)

[R. Frederix, S. Frixione, et al]

- Virtual:
  - cutTools (generate n+2 amplitudes)

[V. Hirschi, R. Pittau, M. V. Garzielli, R. Frederix]

V4 V5

	Sept 09	Dec 09	Mar 10	June 10	Sept 10	Dec 10
MG	MadGraph v4					
		Development v5			Release core MG v5	
ME	MadEvent v4					
					Start dvlpt. ME v5	
BSM	FeynRules interface v4 + USRMOD2					
			Dvlpt. FR for v5+ autom. HELAS		Generic MG5	
NLO V	Dvlpt. CutTools		Physics results v4			
				Dvlpt. CutTools v5	Physics res. v5	
NLO R	Dvl. MadFKS		Physics results MadFKS + stable MadDipole			
					Dvl.MadFKS v5	
Tools	MadWeight, MadOnia, etc. released and stable for ME v4					
					Move to ME v5	

Conclusion

- MG/ME v4 is a mature, well established and stable code with many features for BSM and QCD physics and numerous peripheral tools
- MG5 is available with important and unprecedented improvements in all directions.
- Still many new features to come in the near future