# Update On MadGraph5

Olivier Mattelaer FNRS

MG5: J. Alwall / M. herquet / F. Maltoni / T. Stelzer ALOHA: P. Aquino / W. Link / F. Maltoni / T. Stelzer UFO: C. Degrande / C. Duhr / B. Fuks / D. Grellsheid T. Reiter AMC@NLO: V. Hirschi, R.Frederix, M. Zaro, F.Maltoni, R. Pittau, S. Frixione, P. Torrielli

and a lot of external collaborators















UFO/ALOHA



















\varTheta 🔿 🕥 MadGraph Home Page 🗙 🕀	
← → C ③ madgraph.hep.uiuc.edu	☆ <b>₹</b>
Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation	
The MadGraph homepage UCL UIUC Fermi by the MG/ME Development team	
GenerateMyClusterDownloadsProcessRegisterToolsDatabaseStatus(needs registration)Wiki/DocsAdmin	

#### Generate processes online using MadGraph 5

To improve our web services we request that you register. Registration is quick and free. You may register for a password by clicking <u>here</u>. You can still use **MadGraph 4** <u>here</u>.

Code can be generated either by:

🛟 Fermilab

I. Fill the form	<b>1</b> :	
Model:	SM	Model descriptions
Input Process:		Examples/format
	Example: $p p > w + j j Q$	ED=3, w+>l+vl
p and j definiti	ions: (p=j=d u s c d~ u~ s~	c~ g 🗘
sum over lepto	ons: [I+ = e+, mu+ ta+; I-	= e-, mu- ta-; vl = ve, vm, vt; vl~ = ve~, vm~, vt~
Submit		
II. Upload the <u>Process card e</u> proc_card form <u>Choose File</u> N	e proc_card.dat examples mat MadGraph 5 🛟 No file chosen	and send it to the server.

#### Johan Alwall - The Vision of MG/FR

\*





#### MadEvent Card for p p > t t~h, h > b b~, (t > b w+, w+ > mu+ vm), (t~>b~w-, w- > mu- vm~)



Last Update: Mon Apr 16 23:53:33 CEST 2012

PHENO 2012 : Madgraph 5





#### Results in the sm for p p > W+, W+ > e+ ve , p p > W+ j, W+ > e+ ve , p p > W+ j j, ...

#### **Available Results**

Run	Collider	Banner	Cross section (pb)	Events	Data	Output	Action						
			<u>9797 ± 26</u>	10000	parton	LHE	remove run launch pythia						
		no ISR	2304 + 43	2442	pythia	LOG STDHEP LHE	remove run						
run_01	P P 7000 x 7000 GeV	with ISR		<u>2374 ± 45</u>	2442	pgs	LOG LHCO	remove run					
			with ISR	with ISR	with ISR	with ISR	with ISR	with ISR	6516 + 46	6651	pythia	LOG STDHEP LHE	remove run launch detector simulation
									$0510 \pm 40$		pgs	LOG LHCO	remove run

Main Page



## MadGraph5



#### Remove ALL límitations of MadGraph4

□ speed



## MadGraph5



- Remove ALL límitations of MadGraph4
  - □ speed
  - number of particles



### number of particles





## MadGraph5



- Remove ALL límitations of MadGraph4
  - □ speed
  - number of particles
  - 🛛 type of interactions

### **Type of Interactions**



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Johan Alwall - The Vision of MG/FR

26

this

### **Type of Interactions**



Effective Theory

multí fermíon ínteractíons

#### Fermilabs well as the Alwall-The Vision of MG/FR tures 26 (triplet/sextet)

this



# MadGraph5



- Remove ALL límitations of MadGraph4
  - speed
  - number of particles
  - type of interactions
  - modularity / flexibility of the code
  - user-friendly (command interface)



# MadGraph5



- Remove ALL límitations of MadGraph4
  - □ speed
  - number of particles
  - 🛛 type of interactions
  - modularity / flexibility of the code
  - user-friendly (command interface)
- Output the square matrix element for Pythias







UFO/ALOHA









#### NFO = Universal Feynrules Output

New Model Format

□ Gosam/Herwig++/MG5

□ Fully generic color/Lorentz/...

 Automatic Creation of HELAS routine for ANY BSM theory
Fortran / C++/Python







#### **ALOHA**

# ALOHA Google translate

From: UFO 🔽 🔄 To: Helicity

Translate

#### Type text or a website address or translate a document.







ستأججو والأفت أتهش

**Tim Stelzer** 

to both inciding and marking

WESLEY J. CHUN

#### **Brussels October 2010**





#### ALOHA

#### ALOHA Google translate

F	rom: UFO	• <b>5</b>	To: Helicity	Translate	Options:	Standard Feynman g Complex-r Loop	(HELAS) gauge nass scher	) me

Type text or a website address or translate a document.







**Tim Stelzer** 

WESLEY J. CHUN





Any BSM should be possible in a fully automatic and efficient way!





Mattelaer Olívíer







<b>FINS</b>	Tools	C

Tools	Utility	Progress	
MadAnalysís5	Plotting distributions	$\left( \begin{array}{c} 100 \\ 10$	Release Candídate



Tools	utility	Progress
MadAnalysís5	Plotting distributions	Release Candídate
Decay Package	Fully automatic width computation Possibility to decay final state particles	60 %

fns

Tools	5
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Tools	utility	Progress
MadAnalysís5	Plotting distributions	Release Candídate
Decay Package	Fully automatic width computation Possibility to decay final state particles	60 %
MadWeight5	Specífic integrator for the Matrix Element Method	ín beta

fn's





Mattelaer Olívíer





 $\frac{d\sigma_{\rm MC@NLO}}{dO} = \left| \frac{\partial \Phi_{\rm MC}}{\partial \Phi_{\rm MC}} \right| \mathcal{F}$ 

Real emission:

dO

Mattelaer Olívíer



### MadLoop



Cuttools / OPP





Process	Generation time <sup>1</sup>		Output size <sup>2</sup>		Compilation time <sup>3</sup>		Running time <sup>4</sup>	
d d~ > u u~	8.750 s	5.378 s	200 Kb	268 Kb	0.931 s	2.996 s	0.0088 s	0.0094 s
d d~ > d d~ g	17.04 s	104.8 s	124 Kb	1.7 Mb	4.799 s	19.181 s	0.64 s	0.74 s
d d~ > d d~ u u~	22.50 s	2094 s	232 Kb	3.3 Mb	37.75 s	45.02 s	1.93 s	2.34 s
gg>gggg	38 min	×	25 Mb	×	211 min	×	72 min	×
u d~ > w+ g g g	123 s	×	1Mb	×	43 s	×	121 s	×
u d~ > w+ g g g g	64 min	×	17 Mb	×	9 min	X	137 min	×

<sup>1</sup>: Process generated retaining all contribution with massive top and bottom quarks. MadLoop5 = ♦ <sup>2</sup>: Of the equivalent matrix.f file. <sup>4</sup>: Per PS points, Color/Helicity summed.

MadLoop4 = ♦



## AMC@NLO IN MADGRAPH

Marco Zaro has rewritten MadFKS in Madgraph 5:

- \* "MadFKS from real" is identical in structure and function as current MadFKS for MadGraph 4. Working without problems, but not as well tested yet
- \* "MadFKS from Born" allows for more efficient combination of integration channels, reducing one of the major limitations of current MadFKS. In particular, it allows for a Monte-Carlo sum over the real-emission processes (with FKS damping) contributing to a single Born process.
  - Still needs to be tested and validated. Unfortunately, first tests not as promising as I had hoped for...
- \* No complications for aMC@NLO (structure identical to MadFKS: if MadFKS is working, so is aMC@NLO)

Rikkert Frederix, University of Zurich









https://launchpad.net/madgraph5

Mattelaer Olívíer







MG5 is available on the web
Big improvement compare to MG4



https://launchpad.net/madgraph5







- MG5 is available on the web
- ∃ Big improvement compare to MG4
- Any BSM theory can be runned in MG5 in a fully automatic way



https://launchpad.net/madgraph5







- MG5 is available on the web
- Bíg improvement compare to MG4
- Any BSM theory can be runned in MG5 in a fully automatic way
- MBG
- Varíous tools available to help the community

https://launchpad.net/madgraph5


## Conclusion





- □ MG5 is available on the web
- Bíg improvement compare to MG4
- Any BSM theory can be runned in MG5 in a fully automatic way



- Varíous tools available to help the community
- Large work to have a Fully automatic NLO generator

https://launchpad.net/madgraph5



### More information



# fn's Computing the widths



- □ mg5> compute\_widths Z
  - □ First evaluate 2>2 and 2>3 contribution
  - Compute ONLY the relevant contribution
  - Write the new param\_card.dat









- Inclusion of new output
  - MadDarkMatter
  - Madweight
  - Ω...





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diagram 19 QCD=5





Inclusion of new output 2\_
 MadDarkMatter
 MadWeight

n

MadLoop/AMC@NLO

usermod for UFO model

MadAnalysis5



diagram 19 QCD=5







- Inclusion of new output
  - MadDarkMatter
  - Madweight
  - ... 0
- MadLoop/AMC@NLO
- usermod for UFO model
- MadAnalysis5
- color ordered amplitude



diagram 19 QCD=5







- Inclusion of new output
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- usermod for UFO model
- MadAnalysis5
- color ordered amplitude
- recursion relations



diagram 19 QCD=5







- Inclusion of new output
  - MadDarkMatter
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  - ... 🛛
- MadLoop/AMC@NLO
- usermod for UFO model
- MadAnalysis5
- color ordered amplitude
- recursion relations
- computing the widths



diagram 19 QCD=5









### **Matrix Element** generation:

Process	MadGraph 4	MadGraph 5	Subprocesses	Diagrams
pp  ightarrow jjj	$2 \min$	22 s	34	307
$pp  ightarrow jjl^+l^-$	$23 \min$	26 s	108	1216
$pp  ightarrow jjje^+e^-$	$60 \min$	132 s	141	9012
$u\bar{u} \rightarrow e^+e^-e^+e^-e^+e^-$	$51 \min$	75 s	1	3474
gg  ightarrow ggggg	3 hours	$5 \min$	1	7245
$pp  ightarrow jj(W^+  ightarrow l^+  u_l)$	$10 \min$	19 s	82	304
$pp \rightarrow t\bar{t}$ +full decays	$6\mathrm{h}$	29 s	27	45
pp  o  ilde q/ ilde g   ilde q/ ilde g	$14 \min$	63 s	313	475
$gg  ightarrow ( ilde{g}  ightarrow u ar{u}  ilde{\chi}_1^0) ( ilde{g}  ightarrow u ar{u}  ilde{\chi}_1^0)$	$5 \min$	$7 \mathrm{s}$	1	48
$pp \rightarrow (\tilde{g} \rightarrow jj\tilde{\chi}_1^0)(\tilde{g} \rightarrow jj\tilde{\chi}_1^0)$		30s	144	11008

	Drocoss	Functio	on calls	Run time		
	1100655	MG 4	MG 5	MG 4	MG 5	
	$u\bar{u} \to e^+e^-$	8	8	$< 6\mu s$	$< 6\mu s$	
	$u\bar{u} \rightarrow e^+e^-e^+e^-$	110	80	$0.22 \mathrm{ms}$	$0.14 \mathrm{\ ms}$	
	$u\bar{u} \to e^+e^-e^+e^-e^+e^-$	Function callsRun timeMG 4MG 5MG 4MG 588 $< 6\mu s$ $< 6\mu s$ 110800.22 ms0.14 ms6668377546.5 ms19.0 ms66 $< 4\mu s$ $< 4\mu s$ 161627 $\mu s$ 27 $\mu s$ 85670.42 ms0.31 ms74851510.8 ms6.75 ms1601161.24 ms0.80 ms146896035.7 ms17.2 ms423384 $\mu s$ 83 $\mu s$ 3101971.88 ms1.15 ms33721876141 ms34.4 msGraph 5 $\mathcal{L}$ $\mathcal{L}$ $\mathcal{L}$				
Matrix Element	$u \bar{u}  ightarrow d \bar{d}$	6	6	$< 4\mu s$	$< 4\mu s$	
oveluetien	$u\bar{u}  ightarrow d\bar{d}g$	16	16	$27~\mu { m s}$	$27~\mu { m s}$	
evaluation	$u \bar{u}  ightarrow d \bar{d} g g$	85	67	$0.42 \mathrm{~ms}$	$0.31 \mathrm{ms}$	
(Fortran)	$u \bar{u}  ightarrow d \bar{d} g g g$	748	515	10.8 ms	$6.75 \mathrm{\ ms}$	
	$u \bar{u}  ightarrow u \bar{u} g g$	160	116	$1.24 \mathrm{\ ms}$	$0.80 \mathrm{ms}$	
	$u\bar{u}  ightarrow u\bar{u}ggg$	1468	960	$35.7 \mathrm{\ ms}$	$17.2 \mathrm{\ ms}$	
	$u \bar{u}  ightarrow d \bar{d} d \bar{d}$	42	33	$84 \ \mu s$	$83 \ \mu s$	
	$u \bar{u}  ightarrow d \bar{d} d \bar{d} g$	310	197	$1.88 \mathrm{ms}$	$1.15 \mathrm{\ ms}$	
	$u\bar{u} \rightarrow d\bar{d}d\bar{d}gg$	3372	1876	141 ms	34.4 ms	
Fermilab	Johan Adwall - Th	e 1830o	า <i>ด</i> 75MG	<b>/42</b> 5 ms	6.6 ms	
Mattelaer Olivier	PHENO 2012 : Madgra	ph 5			26	



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mg5>help				



### □ Nice Interactive session

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Níce Interactive session
 Auto-completion

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mg5>help		

- Níce Interactive session
  - □ Auto-completion
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- □ Símple command set

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## Output



- Madevent (Fortran)
- □ Standalone (Fortran)
- $\Box$  standalone(C++)  $\leftarrow$  NEW
- □ Pythía 8 (C++) ← NEW

	Process	Subpro	cess directories	Channe	els for survey	Directory size		
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ompact and	$pp  ightarrow W^+ jj$	41	4	138	29	438 MB	64 MB	
	$pp  ightarrow W^+ j j j$	73	5	1164	184	842  MB	110 MB	
optimice	$pp  ightarrow W^+ j j j j j$	296	7	15029	1327	$3.8~\mathrm{GB}$	352 MB	
Opconcisc	$pp  ightarrow l^+ l^- j$	12	2	48	8	149 MB	44 MB	
	$pp  ightarrow l^+ l^- jj$	54	4	586	58	612  MB	83 MB	
output for	$pp  ightarrow l^+ l^- j j j$	86	5	5408	368	1.2  GB	151 MB	
	$pp \rightarrow l^+ l^- j j j j$	235	7	63114	2500	$5.3~\mathrm{GB}$	662MB	
MadEvent	$pp  ightarrow t\bar{t}$	3	2	5	4	49 MB	39 MB	
	$pp  ightarrow t ar{t} j$	7	3	45	25	97 MB	56 MB	
	$pp  ightarrow t ar{t} j j$	22	5	417	188	274  MB	98 MB	
	$pp  ightarrow t ar{t} j j j$	34	6	3816	1300	620 MB	209 MB	

Comp







### **fn's** After the initial Goal?



### ALMAN NA MANA A QUINTEE PER LEME A DAMAN A MARKA A M 1.5.55 (спорт) на полнителя на литер на примателя полася на стару алетер на полнителя на полнителя, на полада со село полнителя на полнителя, от полна на полна полнителя на са селот на селот на селот на нарителя разрителя со селот на селот на селот на полнителя на селот селот на селот нателя; MAXING MARKEN OF MARK PRINT 1.5.9 QUITERING AND THE ADDRESS OF A DESCRIPTION OF A 1. у устранения солотис вое на село село воер силонах у едина цело на начел на устранутации на отнанения, солтание начи на техника поседи со село на село на година селова на настояти на на сулат. Style United and the second But Hauff Barry, ... C. (1) Control and В 1 мак има на селетора, В 1 мак има на селетора, В 1 мак има на селетора изпоратора на селетора н Сурта призната състата сърта провоје насе отката и кака отка-стита на отката состата на сърта продоктори и сърта и таката сърта сърта сърта сърта сърта сърта сърта сърта, стра, структ развити словати и слова салоко со салоко са структ, соответства со сурку. A. P. C. MARKET AND A DECK DESCRIPTION OF METHOD AND A DECK. A. P. C. M. C. . The probability of the transmission of the Construction of the second second second second A second s CONTRACTOR AND A LARGE A MARK AND A 1.5.5.5 (parameter carrier and other comparation of the transition of the transition and acceptance of the transition of the transition of the transition and acceptance of the transition of Letter 1, 1, 1, 1 Ly Ji (Britshi), sol traditional and the strain and A second s на селото на кака на кака така се село се село се село се на селото на пределата на селото на селото на селото на селото на селото на селото селото се селото се селото на селото на селото на селото на селото на селото на с $1 \geq 2$ (in the set of the set o E. (A) Constitution of the constitution of , it is a parameter of the second state of the second state of the parameter 2000, 2000The particular sectors and an entry of the sector С установание на правлатие се наститит, нове настична настична настична на предоктата на предоктат На предоктата на предокта THE REAL PLACE AND ADDRESS OF A DRIVEN

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### fn's After the initial Goal?

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Mattelaer Olivier

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### **fn's** After the initial Goal?



### Сурскултения императивных положити положити положити по во другитель по положителя получить положити как полько положителя положителя (польких и как польки положителя) по други и положителя во как пол типа нада положите и как польки польки получителя польки польки польки польки польки получителя и император самат польки, 1.5.9 QUINTERN AND THE ADDRESS OF A DESCRIPTION OF A D Сурук уларных солональных на каконских разражения у адель урак на начал каконских у урак, начал на начал вор солональных начала начал на каконских на начал на глава, каконски на началите на на кулят. 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На страната страната страната страната страната страната. На страната с страната стр 1 П. К. КАТТИНТИТ ТИТИ ТАКАТИТИК, 1941 Н. (ТКК ТАКАТИКИКИ, 2043 МАКАК Н. (ТКК ТАКАТИКИКИ) ТАКАТИКИ КАТКИТИКИ ТАКАТИКИКИ ТАКАТИКИ КАТКИТИКИ ТАКАТИКИКИ ТАКАТИКИ КАТКИТИКИ ТАКАТИКИ КАТКИТИКИ ТАКАТИКИ ТАКАТИКИ КАТКИТИКИ ТАКАТИКИ КАТКИТИКИ ТАКАТИКИ ТАКАТИКИ ТАКАТИКИ КАТКИТИКИ ТАКАТИКИ ТАКАТИКИ ТАКАТИКИ КАТКИТИКИ ТАКАТИКИ ТАКАТИКИ ТАКАТИКИ КАТКИТИКИ ТАКАТИКИ ТАКАТИКИ ТАКАТИКИ ТАКАТИКИ ТАКАТИКИ КАТИТИКИ ТАКАТИКИ ТАКАТИКИ ТАКАТИКИ ТАКАТИКИ ТАКАТИКИ КАТИТИКИ ТАКАТИКИ ТАКАТИКИ ТАКАТИКИ ТАКАТИКИ ТАКАТИКИ КАТИТИКИ ТАКАТИКИ ТАКАТИКИ ТАКАТИКИ ТАКАТИКИ ТАКАТИКИ ТАКАТИКИ КАТИТИКИ ТАКАТИКИ ТАКАТИКИ ТАКАТИКИ ТАКАТИКИ ТАКАТИКИ КАТИТИКИ ТАКАТИКИ КАТИТИКИ ТАКАТИКИ ТАКАТИКИТИКИТИ ТАКАТИТИКИ ТАКАТИКИ ТАКАТИТИКИТИКИ ТАКАТИТИКИ ТАКАТИТИ ТАКАТ Not possible to detail everything анализарания си пользанирали станция пользанирали состания пользанирали состания пользание состания на общество состания общество общес са настраба настраба се на уческу на се на уческу настраба и тока се на настраба на се на се на се на се на се на се на настраба настраба на се на се на се на се на се на настраба настраба на се на се на се на се на се на настраба на се на настраба на се на настраба на се на с на се Maria Maria Carlo and Participation of the second Construction and the second reaction of the states A provide the second sec CONTRACTOR AND A CONTRACTOR OF A DESCRIPTION OF A DESCRIPANTE A DESCRIPANTE A DESCRIPANTE A DESCRIPTION OF A Explosing extension and provide any property and a method a constraint of an accept and accept on a method accept on the method a model along and accept on the method accept on the region, any any accept on a method accept on the region, any accept on a method accept on the method of the method accept on the region of the method accept on a method accept on the set of a method accept on the set of the method accept on the set of a method accept on the method of the set of a method accept on the set of a set of the set of the set of a method accept on the set of a set of the set of the set of the set of a method accept on the set of the se 1. 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Improve Phase-space integration





- Improve Phase-space integration
- automatic order restriction for any model

mg5>display coupling\_order

QCD : weight = 1 QED : weight = 2





Improve Phase-space integration

automatic order restriction for any model

```
mg5>display coupling_order
QCD : weight = 1
QED : weight = 2
mg5>generate p p > w- > b b~ e+ ve j j
INFO: Checking for minimal orders which gives processes.
INFO: Please specify coupling orders to bypass this step.
INFO: Trying coupling order WEIGHTED=8
INFO: Trying coupling order WEIGHTED=9
INFO: Trying coupling order WEIGHTED=10
INFO: Trying process: g g > w- > b b~ e+ ve d u~ WEIGHTED=10
INFO: Process has 63 diagrams
```

If no coupling order specify: take minimal weight





Improve Phase-space integration

automatic order restriction for any model

mg5>display coupling\_order QCD : weight = 1 QED : weight = 2 mg5>generate p p > w- > b b~ e+ ve j j INFO: Checking for minimal orders which gives processes. INFO: Please specify coupling orders to bypass this step. INFO: Trying coupling order WEIGHTED=8 INFO: Trying coupling order WEIGHTED=9 INFO: Trying coupling order WEIGHTED=10 INFO: Trying process: g g > w- > b b~ e+ ve d u~ WEIGHTED=10 INFO: Process has 63 diagrams QED=4, QCD=2

If no coupling order specify: take minimal weight









Check that the param\_card is compatible with the model





- Check that the param\_card is compatible with the model
- MSSM will support SLAHI card





- Check that the param\_card is compatible with the model
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- Improve user interface





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- D Possibility to compute partial width (and BR)





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- Possibility to compute partial width (and BR)
- Improving the gridpack





- Check that the param\_card is compatible with the model
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- Improve user interface
  - configuration files
  - New interface for madevent
  - □ Easy to install pythia-pgs/Delphes/...
- D Possibility to compute partial width (and BR)
- Improving the gridpack
- add a cut forbidding on-shell particles
  but allowing off-sheel contribution (\$)



\$ explanation



pp > e + e - ## Z





\$ explanation







BW cutt =5 (small for the example)



\$ explanation







\$ explanation





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UFO/ALOHA











Avoid multiple output model written by FR.





- Avoid multiple output model written by FR.
- Have the generator to adapt to the model and not the opposite.





- Avoid multiple output model written by FR.
- Have the generator to adapt to the model and not the opposite.
- Avoid any possible limitations
  - 🗆 color
  - Iorentz structure
  - number of particles in a vertex
  - 🗆 gauge





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- □ Joint model for MG5/GOSAM/Herwig++





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#### FORMAT





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#### Universal FeynRules Output (UFO)

#### particles.py:

 $G = Particle(pdg_code = 21, name = 'G', antiname = 'G', spin = 3, color = 8, mass = 'ZERO', width = 'ZERO', texname = 'G', texname = 'G', antitexname = 'G', line = 'curly', charge = 0, LeptonNumber = 0, GhostNumber = 0)$ 

#### lorentz.py: VVV1 = Lorentz(name = 'VVV1', spins = [ 3, 3, 3 ], Structure = $'P(3,1)^*Metric(1,2) P(3,2)^*Metric(1,2) P(2,1)^*Metric(1,3) +$ $P(2,3)^*Metric(1,3) +$ $P(1,2)^*Metric(2,3) P(1,3)^*Metric(2,3)')$

#### couplings.py:

GC\_4 = Coupling(name = 'GC\_4', value = '-G', order = {'QCD':1})

#### vertices.py:

#### 🛟 Fermilah

#### Johan Alwall - The Vision of MG/FR





Idea: Evaluate m for fixed helicity of external particles.



 $M = \bar{u}\gamma^{\mu}v \ P_{\mu\nu} \ \bar{u}\gamma^{\nu}v$ 

diagram 1 QED=2





Idea: Evaluate m for fixed helicity of external particles.



QED=2

diagram 1

 $M = \overline{u} \gamma^{\mu} v P_{\mu\nu} \overline{u} \gamma^{\nu} v$ > Number for a given helicity

CALL IXXXXX(P(0,1),ZERO,NHEL(1),+1\*IC(1),W(1,1)) CALL OXXXXX(P(0,2),ZERO,NHEL(2),-1\*IC(2),W(1,2)) CALL OXXXXX(P(0,3),MT,NHEL(3),+1\*IC(3),W(1,3)) CALL IXXXXX(P(0,4),MT,NHEL(4),-1\*IC(4),W(1,4))





Idea: Evaluate m for fixed helicity of external particles.



diagram 1 QED=2

 $M = \underbrace{\overline{w}}^{\mu} \underbrace{\overline{w}}^{\mu}$ 

CALL IXXXX(P(0,1),ZER0,NHEL(1),+1\*IC(1),W(1,1)) CALL 0XXXX(P(0,2),ZER0,NHEL(2),-1\*IC(2),W(1,2)) CALL 0XXXXX(P(0,3),MT,NHEL(3),+1\*IC(3),W(1,3)) CALL IXXXXX(P(0,4),MT,NHEL(4),-1\*IC(4),W(1,4)) CALL JI0XXX(W(1,1),W(1,2),GG,ZER0,ZER0,W(1,5))





Idea: Evaluate m for fixed helicity of external particles.



diagram 1 QED=2

M = (Ū)<sup>I</sup>(Ū) P<sub>µ</sub>U) (Ū)<sup>I</sup>(Ū)
 → Number for a given helicity
 → Evaluate Interaction by interaction

CALL IXXXXX(P(0,1),ZER0,NHEL(1),+1\*IC(1),W(1,1)) CALL 0XXXXX(P(0,2),ZER0,NHEL(2),-1\*IC(2),W(1,2)) CALL 0XXXXX(P(0,3),MT,NHEL(3),+1\*IC(3),W(1,3)) CALL IXXXXX(P(0,4),MT,NHEL(4),-1\*IC(4),W(1,4)) CALL JI0XXXX(W(1,1),W(1,2),GG,ZER0,ZER0,W(1,5)) CALL IVXXX(W(1,4),W(1,3),W(1,5),GG,AMP(1))





#### $\Box$ Speed:

- □ Basics: Helicity amplitudes. The complexity grows linearly with the number of diagram
- recycling between diagram (so reduces the factorial growth)



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□ spins of the particles

Mattelaer Olívíer





- □ spins of the particles
- One routine by Lorentz structure





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  - MSSM [cho, al] hep-ph/0601063 (2006)





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  - Spin 2 [Hagiwara, al] 0805.2554 (2008)





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SLIH Effective Field Theory Full HEFT Chromo-magnetic Chiral Perturbation Operator Black Holes







# MadWeight



- Tools for the Matrix Element Method
- Reweighting based on the matrix-element

- Technique used for the top mass measurment Now Included in MG5 (still in beta)
- Include ISR corrections
- Better multí-process treatment



# MadWeight



- Tools for the Matrix Element Method
- Reweighting based on the matrix-element

$$\mathcal{P}(\boldsymbol{p}^{vis}|\alpha) = \frac{1}{\sigma_{\alpha}^{vis}} \int d\Phi dx_1 dx_2 |M_{\alpha}(\boldsymbol{p})|^2 W(\boldsymbol{p}, \boldsymbol{p}^{vis})$$

- Technique used for the top mass measurment Now Included in MG5 (still in beta)
- Include ISR corrections
- Better multí-process treatment



# DECAY



- MG is now able to create the decay table for pythia. But the user should provide all the possible decay
- This project will allow to find the relevant channel of integration automatically by checking the relevance of one additional decay



Possibility to add a module for decaying the final state particles with either a part OR the full spin-correlation. For ANY BSM theories

ve~
Associate to each experimental event characterised by  $p^{vis}$ , the probability  $\mathcal{P}(p^{vis}|\alpha)$ to be produced and observed following a theoretical assumption  $\alpha$ 

□ Associate to each experimental event characterised by  $p^{*}$ , the probability  $\mathcal{P}(p^{vis}|\alpha)$  to be produced and observed following a theoretical assumption  $\alpha$ 

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#### is the squared matrix element

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ís the squared matrix element
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ís the phase-space íntegral

□ Associate to each experimental event characterised by  $p^{*}$ , the probability  $\mathcal{P}(p^{vis}|\alpha)$  to be produced and observed following a theoretical assumption  $\alpha$ 

$$\mathcal{P}(\boldsymbol{p}^{vis}|\alpha) = \frac{1}{\sigma_{\alpha}^{vis}} \int d\Phi dx_1 dx_2 |M_{\alpha}(\boldsymbol{p})|^2 W(\boldsymbol{p}, \boldsymbol{p}^{vis})$$

- $\square |M_{lpha}({m p})|^2$  is the squared matrix element
- $\square W(p, p^{vis})$  is the transfer function
- $\Box \int d\Phi dx_1 dx_2$  is the phase-space integral
- $\Box \sigma_{\alpha}^{vis}$  is the cross-section (after cuts)

Introduction ○○●○○○○	My first analysis 000000000	Advanced functionalities	<b>Developer-friendly mode</b>	Summary	
MadAnaly	vsis overview				

#### Scope

- Analysis of event files produced by Monte Carlo tools at parton level, hadron level or after detector simulation.
- Definition of various selection cuts on the input samples.
- Production of histograms for different distributions.
- Results of the analysis summed up by a S/B-like ratio table.

Computing details

- Interface written in Python and ROOT; kernel in C++.
- Possible output in ROOT, HTML, LATEX.

Website

- https://server06.fynu.ucl.ac.be/projects/madanalysis
- Please send us your comments and suggestions (tickets on the wiki).

#### Step 5 : diplaying results

Dataset	# events	Mean	<mark>RMS</mark>	% Underflow	% Overflow
mybkg	42751	48.9768	31.5	0.0	0.4688
mysignal	15939	49.4274	31.7	0.0	0.5338

Histogram number 1 - Statistics

