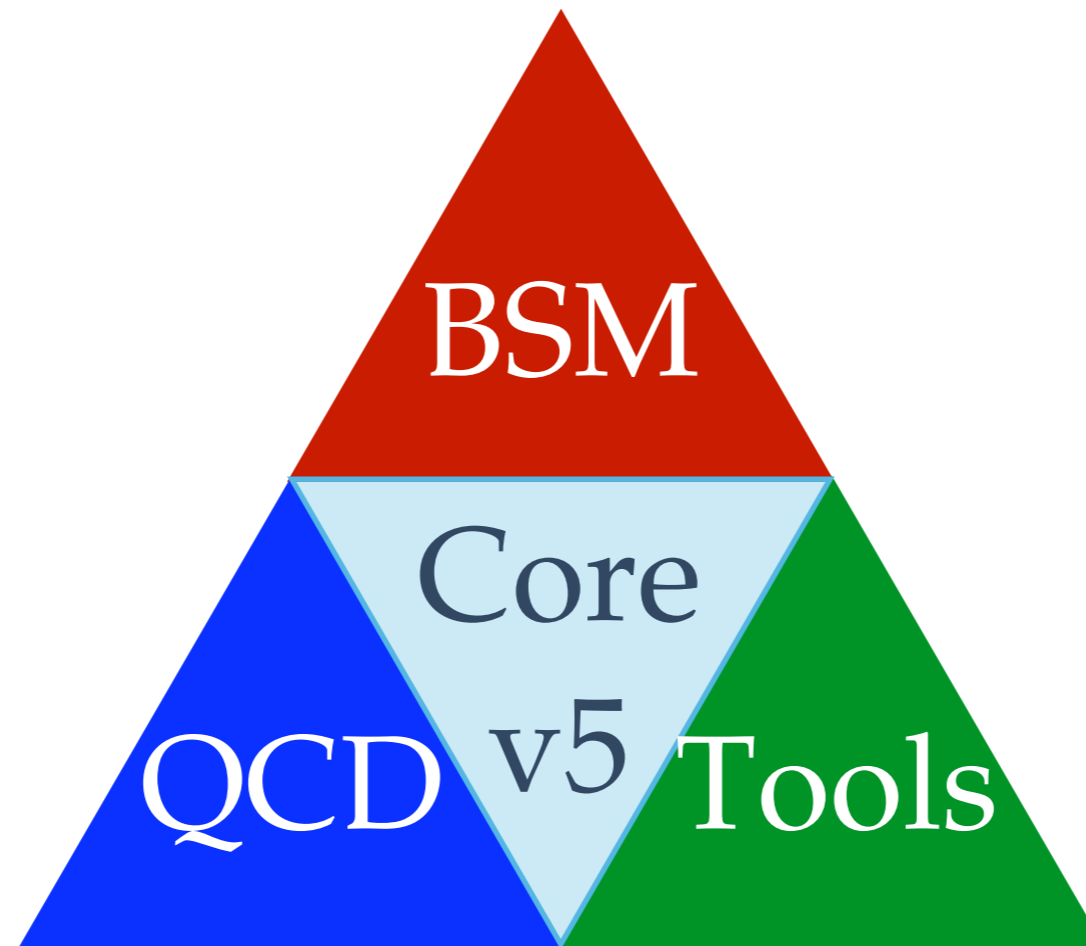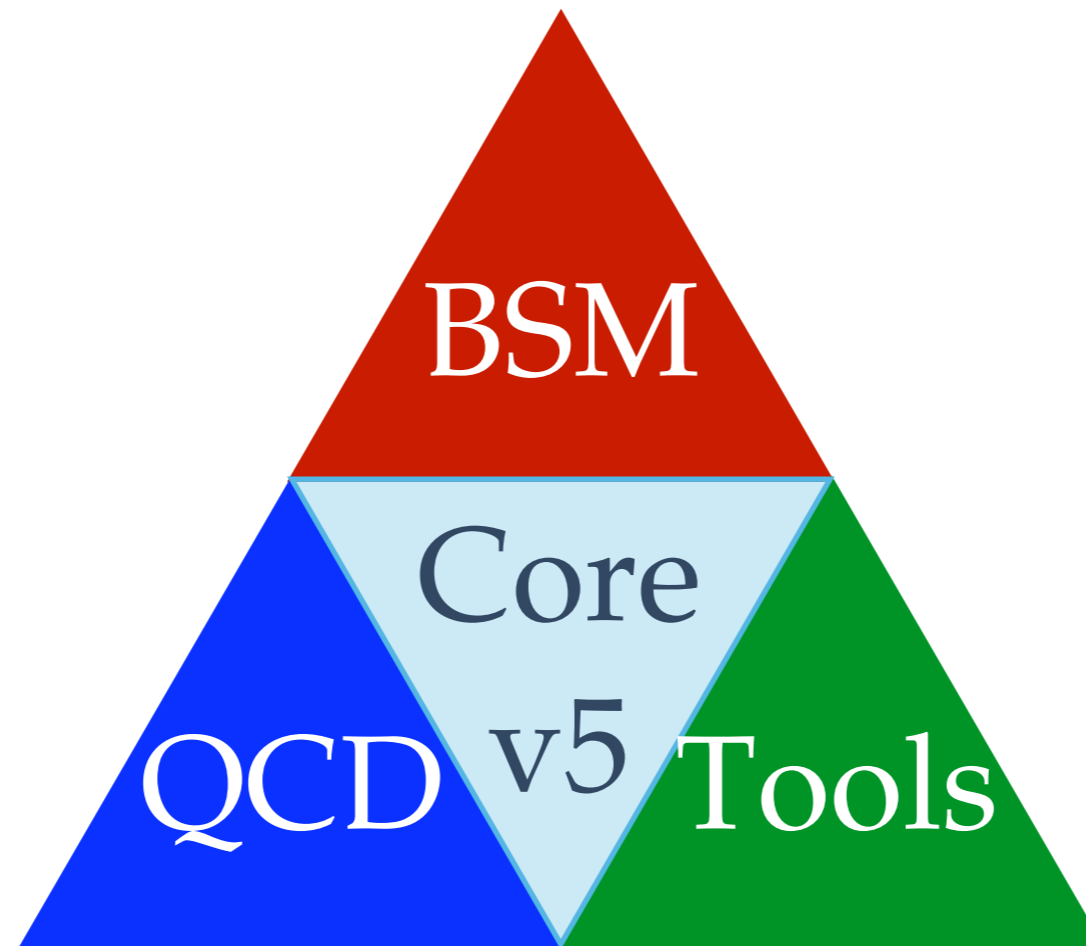# Update On MadGraph5

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
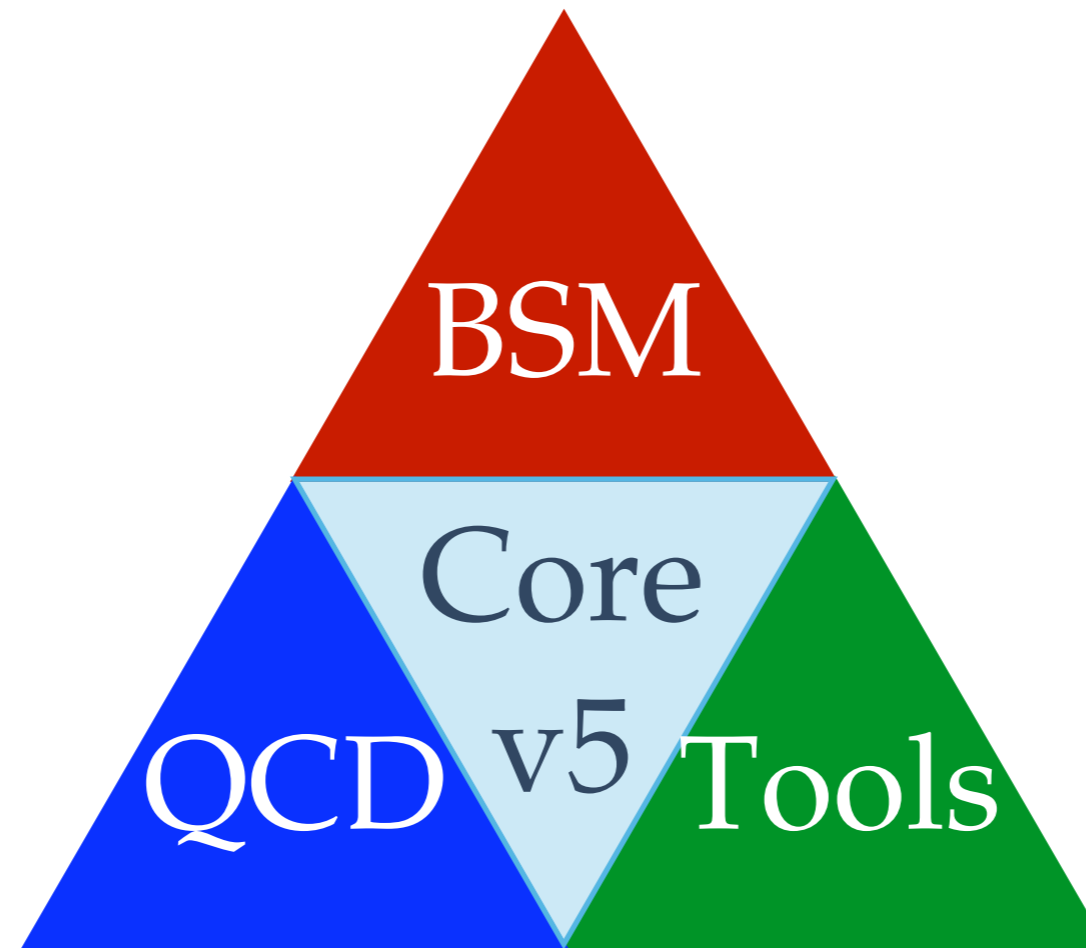AMC@NLO: V. Hirschi, R.Frederix, M. Zaro, F.Maltoni, R. Pittau, S. Frixione, P. Torrielli
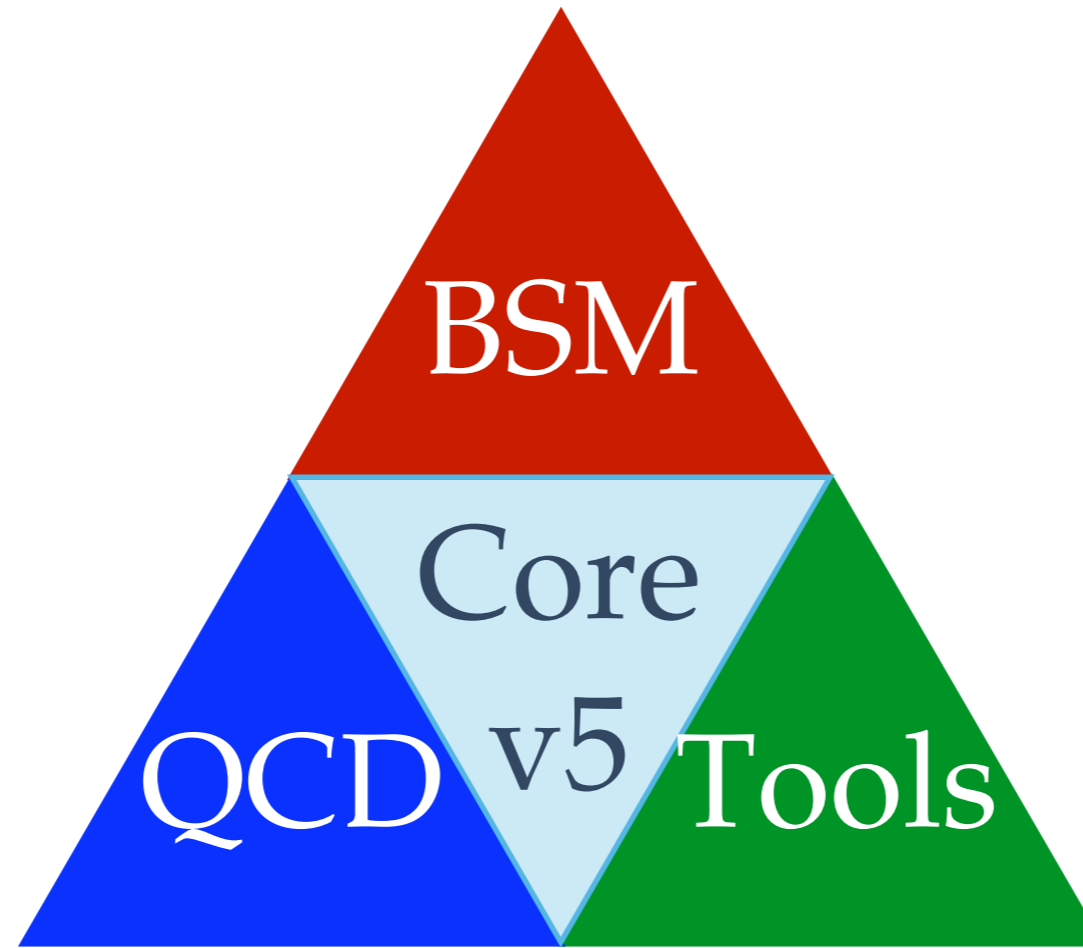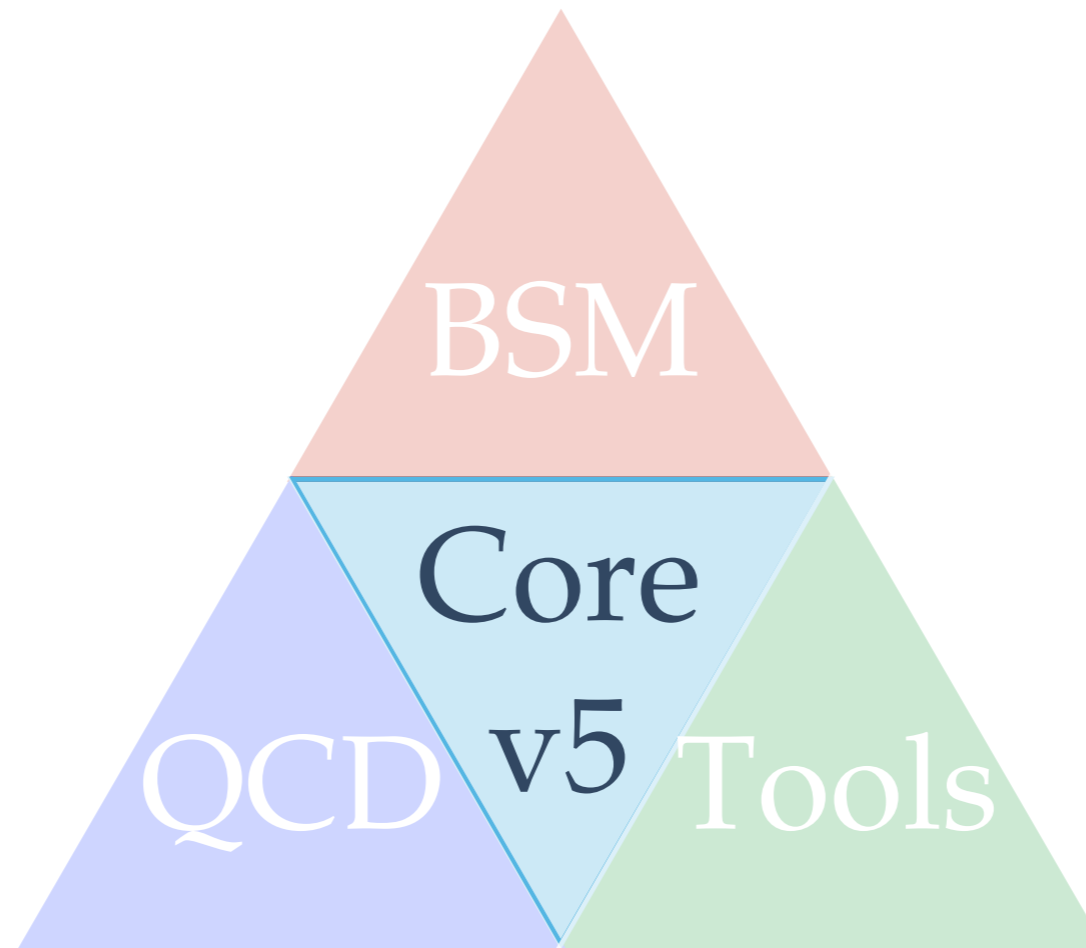
and a lot of external collaborators

UFO / ALOHA

BSM

Core v5

QCD

Tools

madgraph.hep.uiuc.edu

NSF

# High Energy Physics
Illinois

1867 TM

This material is based upon work supported by the National Science Foundation under Grant No. 0426272.

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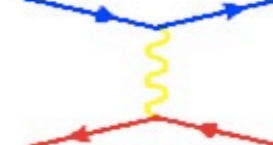
| Generate Process | Register | Tools | My Database | Cluster Status | Downloads (needs registration) | Wiki/Docs | Admin |

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 here.
You can still use **MadGraph 4** here.

Code can be generated either by:

I. Fill the form:

Model: [SM] Model descriptions

Input Process: [   ] Examples/format

Example: p p > w+ j j QED=3, w+ > l+ vl

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

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

(Submit)

II. Upload the proc_card.dat

Process card examples

proc_card format [MadGraph 5]

(Choose File) No file chosen   and (send) it to the server.

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
run_01	p p 7000 x 7000 GeV	no_ISR	9797 ± 26	10000	parton	LHE	remove run launch pythia
			2394 ± 43	2442	pythia	LOG STDHEP LHE	remove run
					pgs	LOG LHCO	remove run
		with_ISR	6516 ± 46	6651	pythia	LOG STDHEP LHE	remove run launch detector simulation
					pgs	LOG LHCO	remove run

Main Page

☐ Remove ALL limitations of MadGraph4

☐ speed

☐ Remove ALL limitations of MadGraph4

    ☐ speed

    ☐ number of particles
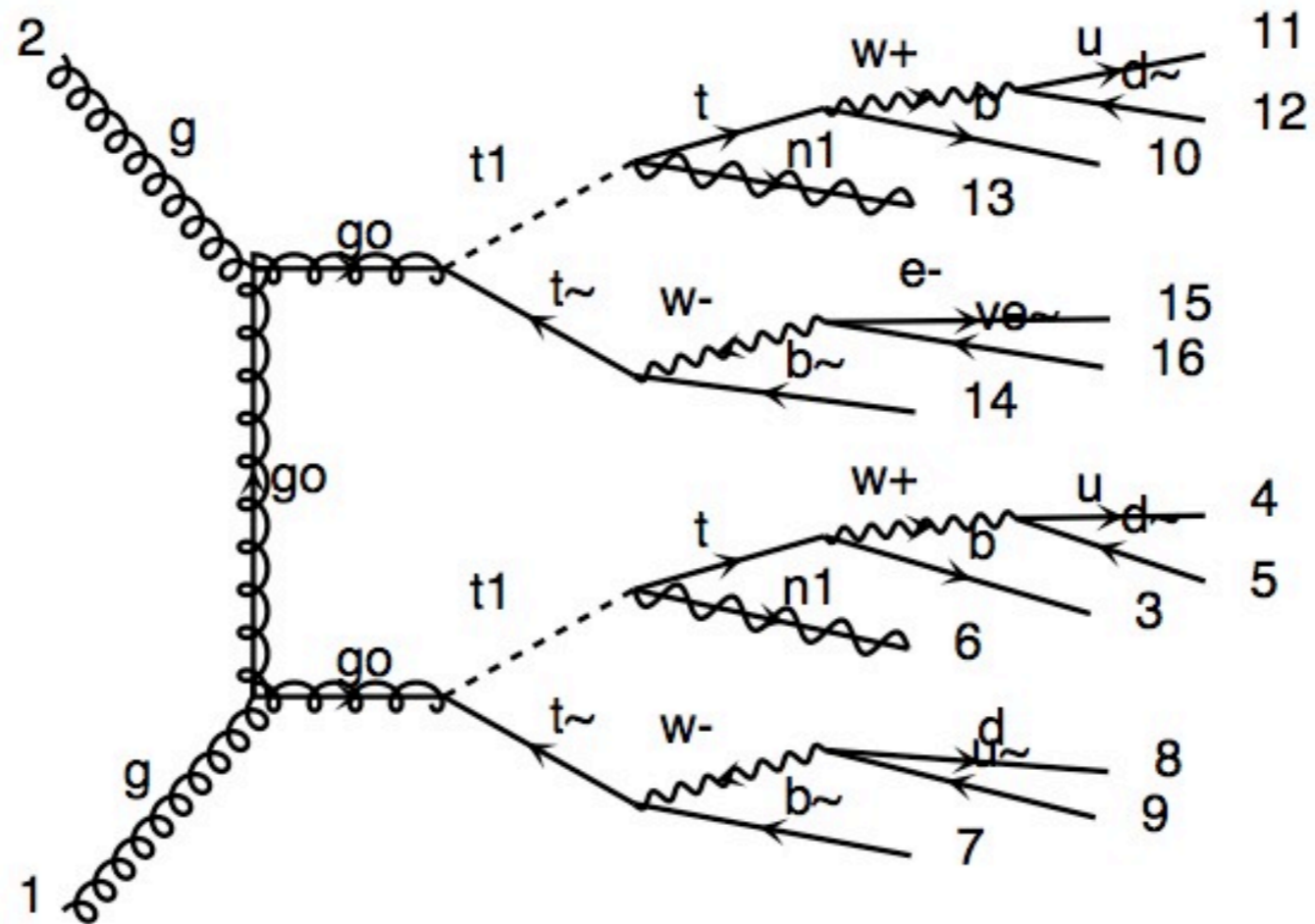
☐ Remove ALL limitations of MadGraph4

☐ speed

☐ number of particles

☐ type of interactions
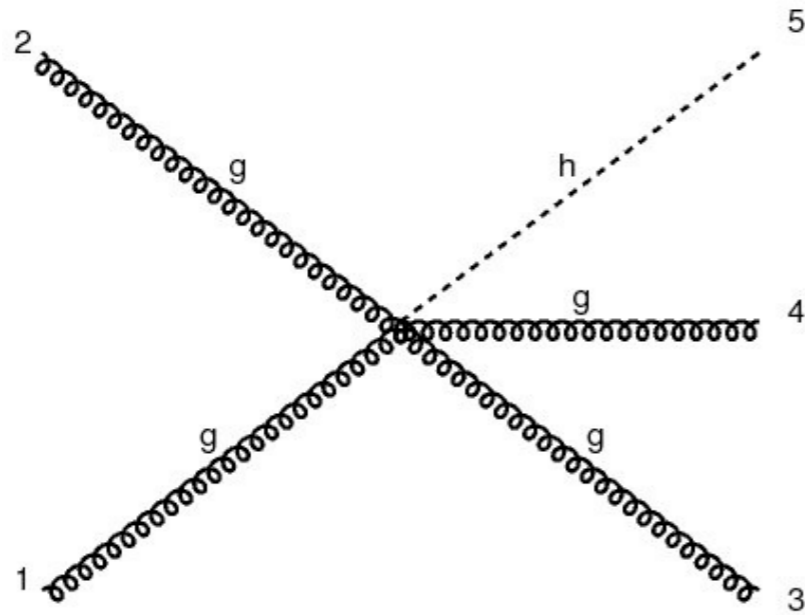
Effective Theory
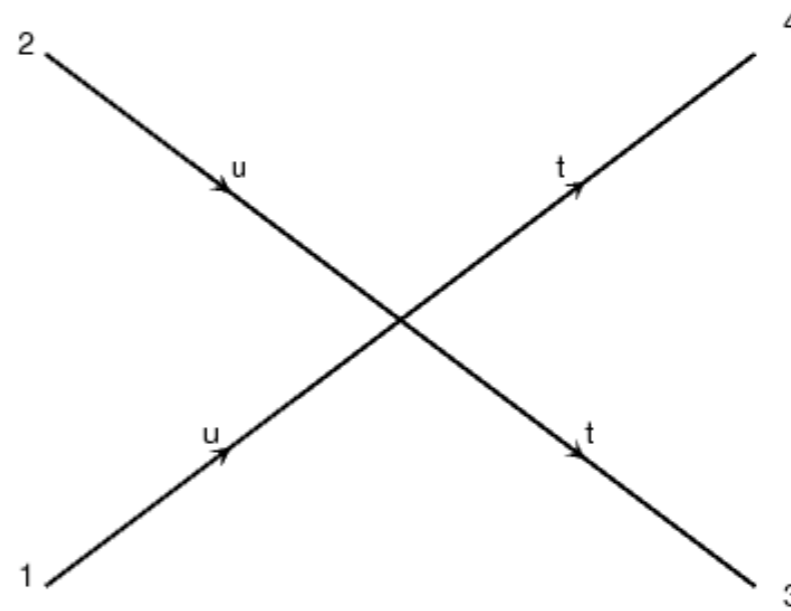
multi fermion interactions
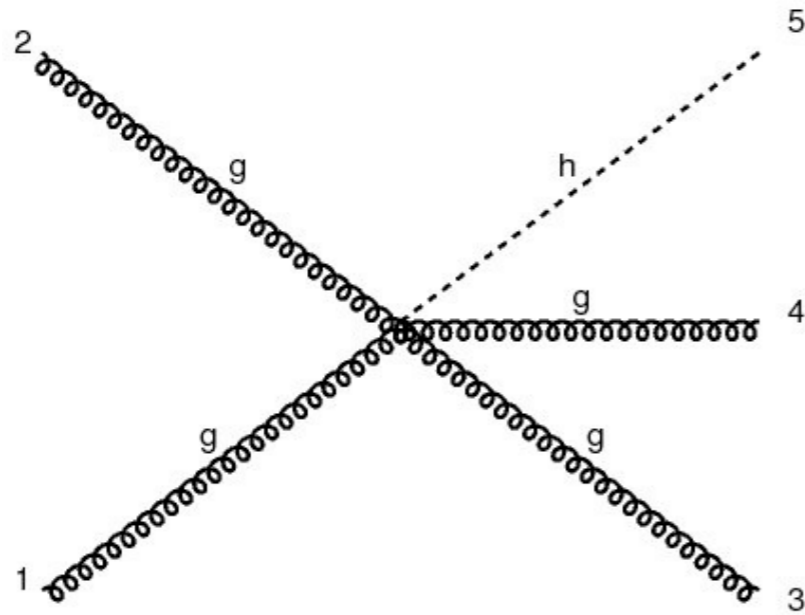
Effective Theory
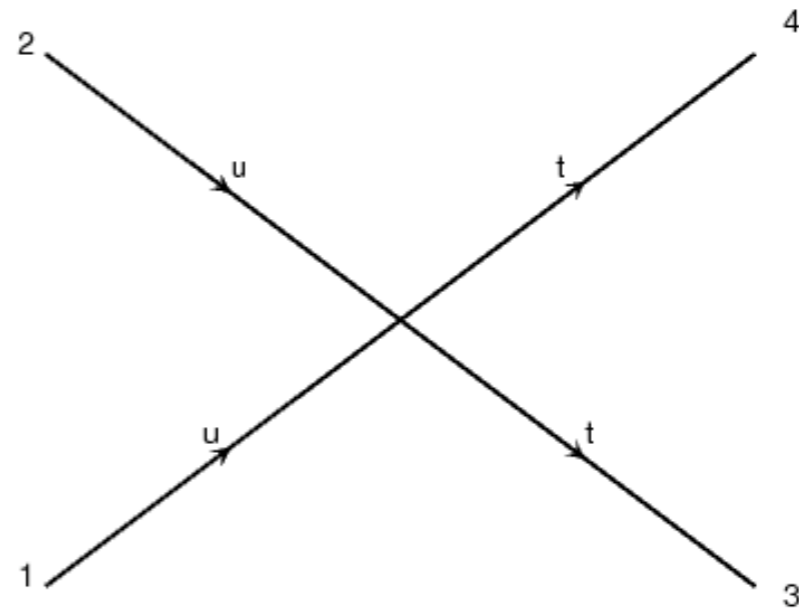
multi fermion
interactions

As well as new color structures
(triplet/sextet)

☐ Remove ALL limitations of MadGraph4

    ☐ speed

    ☐ number of particles

    ☐ type of interactions

    ☐ modularity / flexibility of the code

    ☐ user-friendly (command interface)

MadGraph5

☐ Remove ALL limitations of MadGraph4

    ☐ speed

    ☐ number of particles

    ☐ type of interactions

    ☐ modularity / flexibility of the code

    ☐ user-friendly (command interface)

☐ Output the square matrix element for Pythia8

UFO / ALOHA
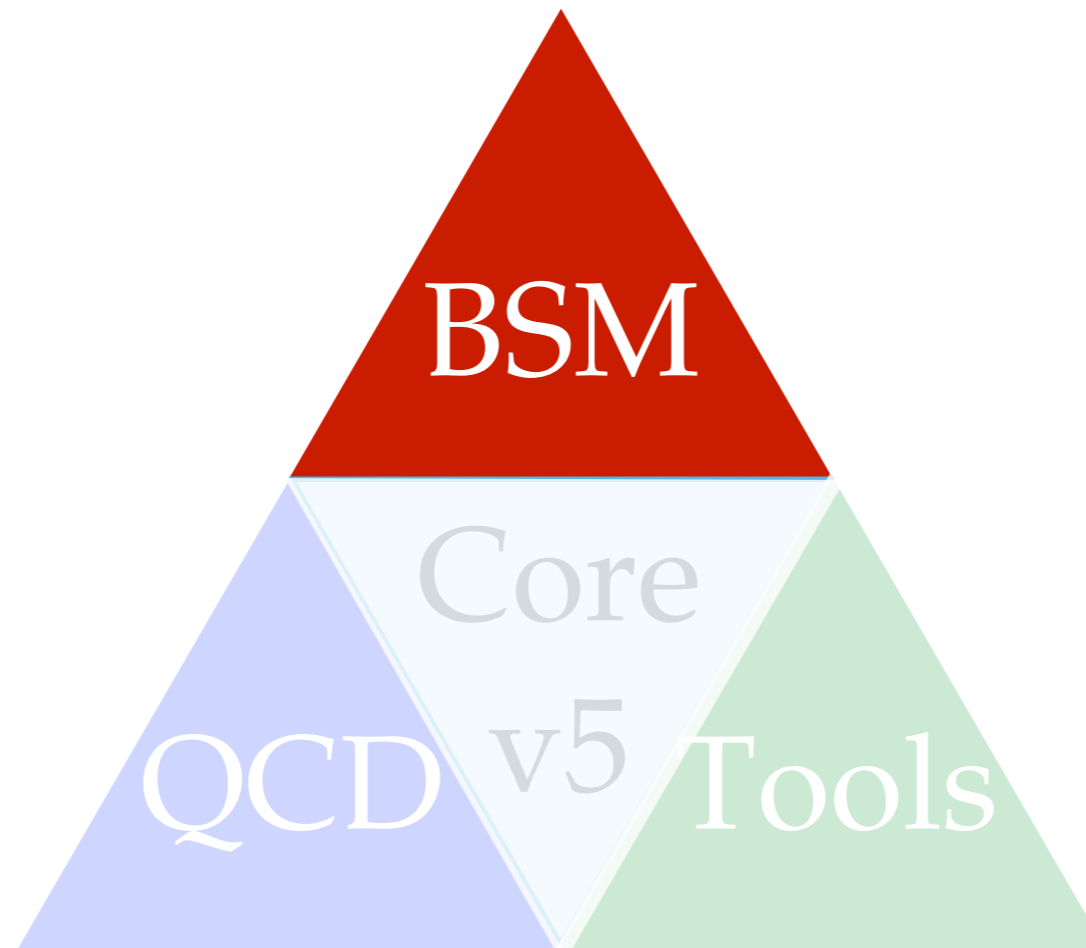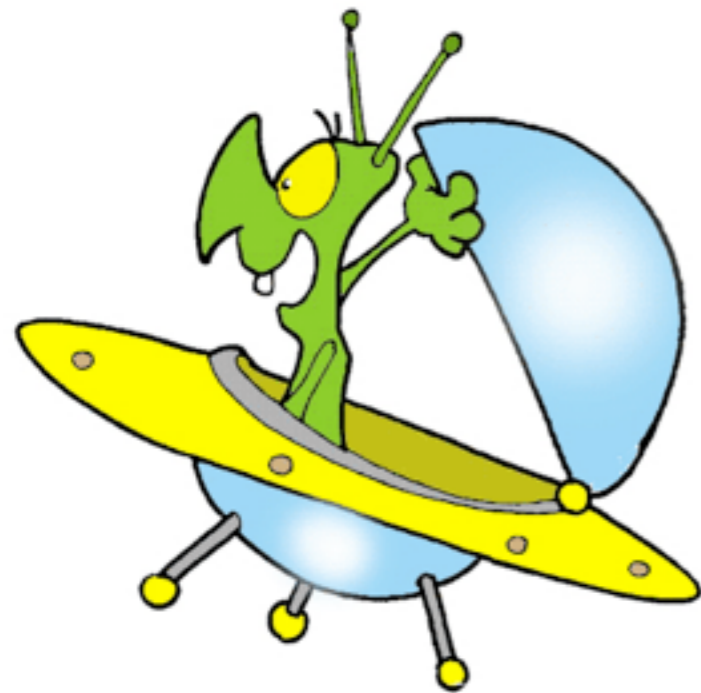
UFO = Universal Feynrules Output

- New Model Format
- Gosam/ Herwig++/ MG5
- Fully generic color/Lorentz/…

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

ALOHA

30

ALOHA

ALOHA
~~Google~~ translate

From: [UFO ▾] ⇄ To: Helicity [Translate] Options: Standard   (HELAS)
                                                            Feynman gauge
                                                            Complex-mass scheme
                                                            Loop
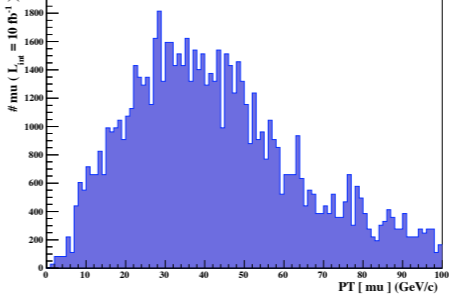
Type text or a website address or translate a document.
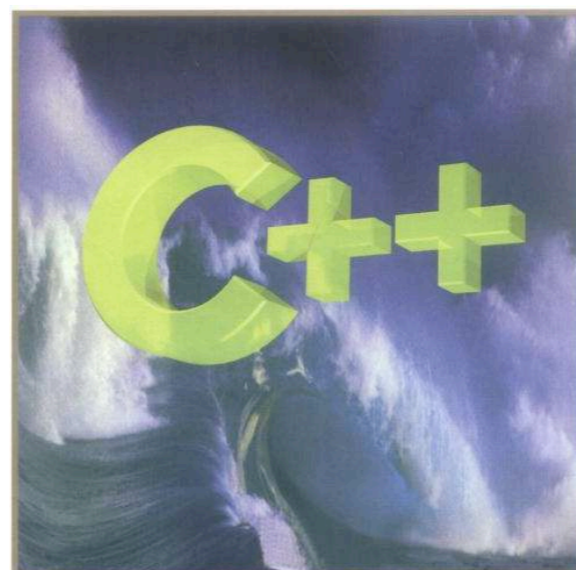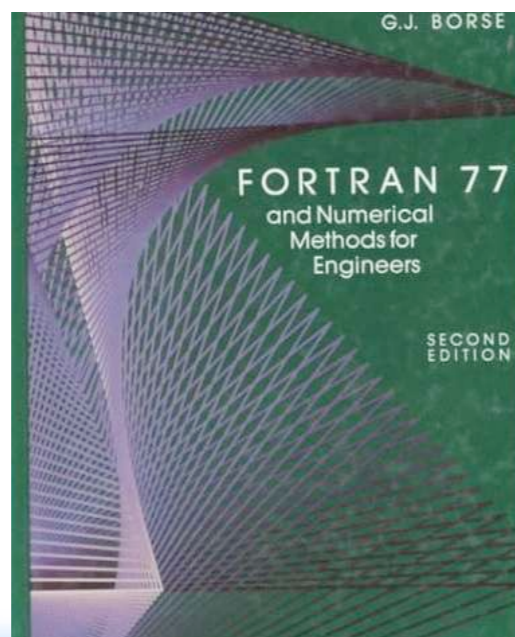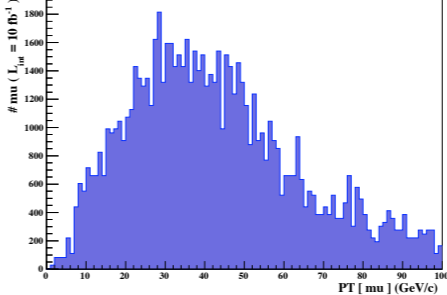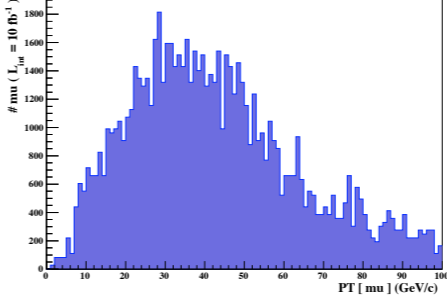
Any BSM should be possible in a fully automatic and efficient way!

BSM

Core
v5

QCD
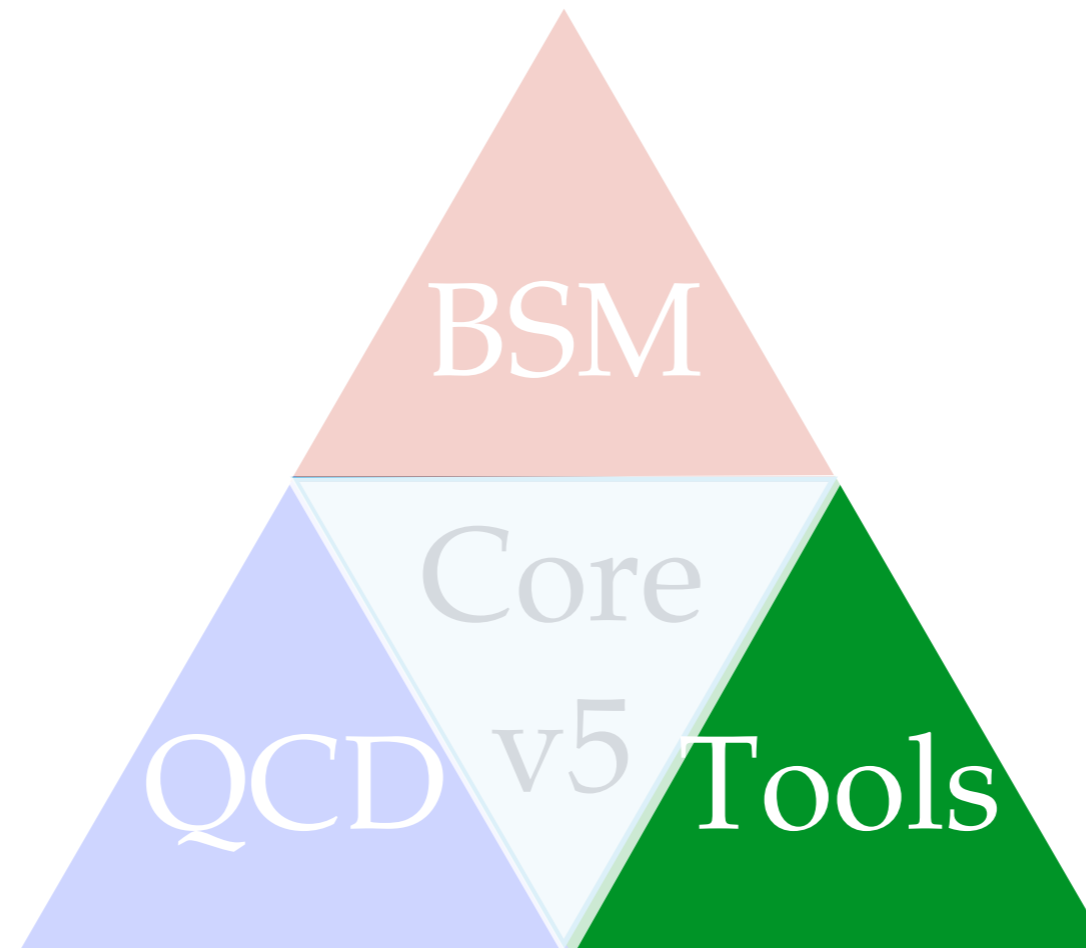
Tools

DECAY
MADWEIGHT
MadAnalysis5

Tools	Utility		Progress
MadAnalysis5	Plotting distributions		Release Candidate

Tools

Tools	Utility	Progress
MadAnalysis5	Plotting distributions	Release Candidate
Decay Package	Fully automatic width computation Possibility to decay final state particles	60 %

Tools

Tools	Utility	Progress
MadAnalysis5	Plotting distributions	Release Candidate
Decay Package	Fully automatic width computation Possibility to decay final state particles	60 %
MadWeight5	Specific integrator for the Matrix Element Method	in beta

MADLOOP
MADFKS
MADGOLEM

MADLOOP
MADFKS
MADGOLEM ⟶ See D. Lopez Talk (15h30)
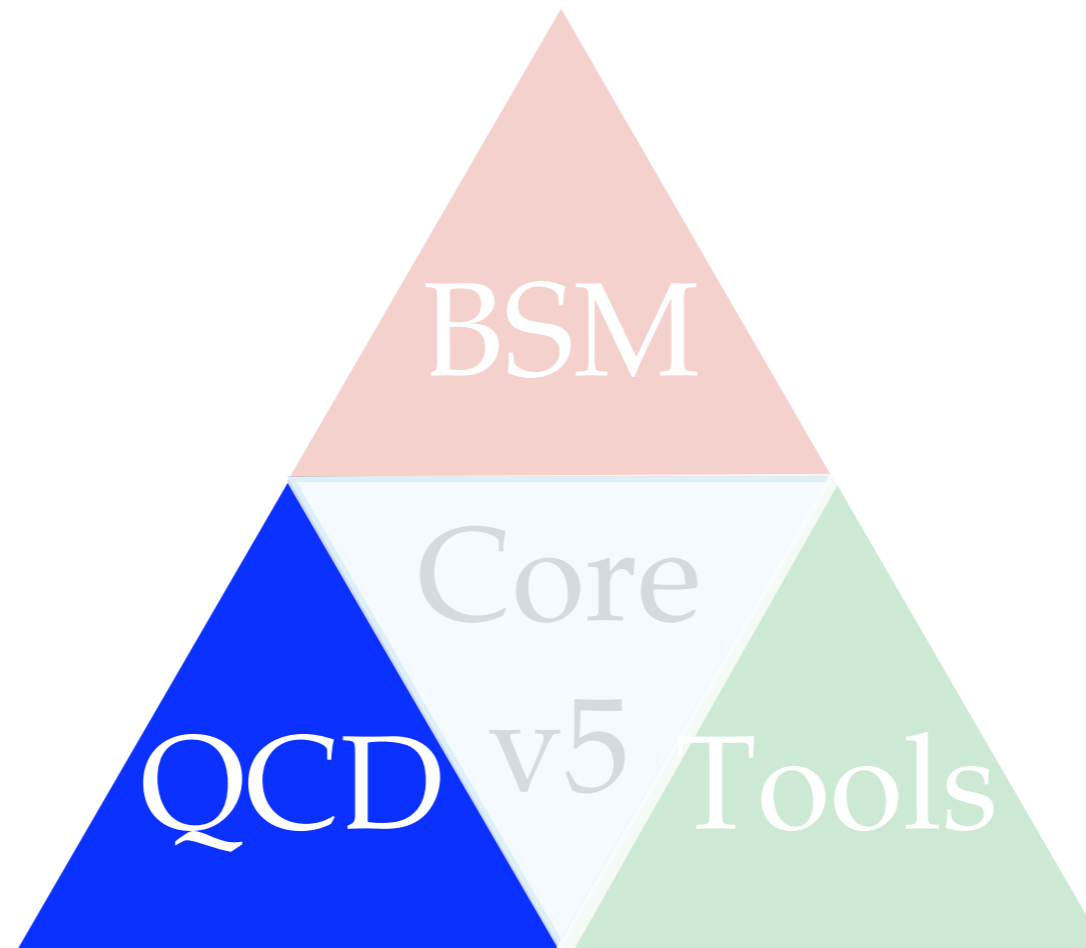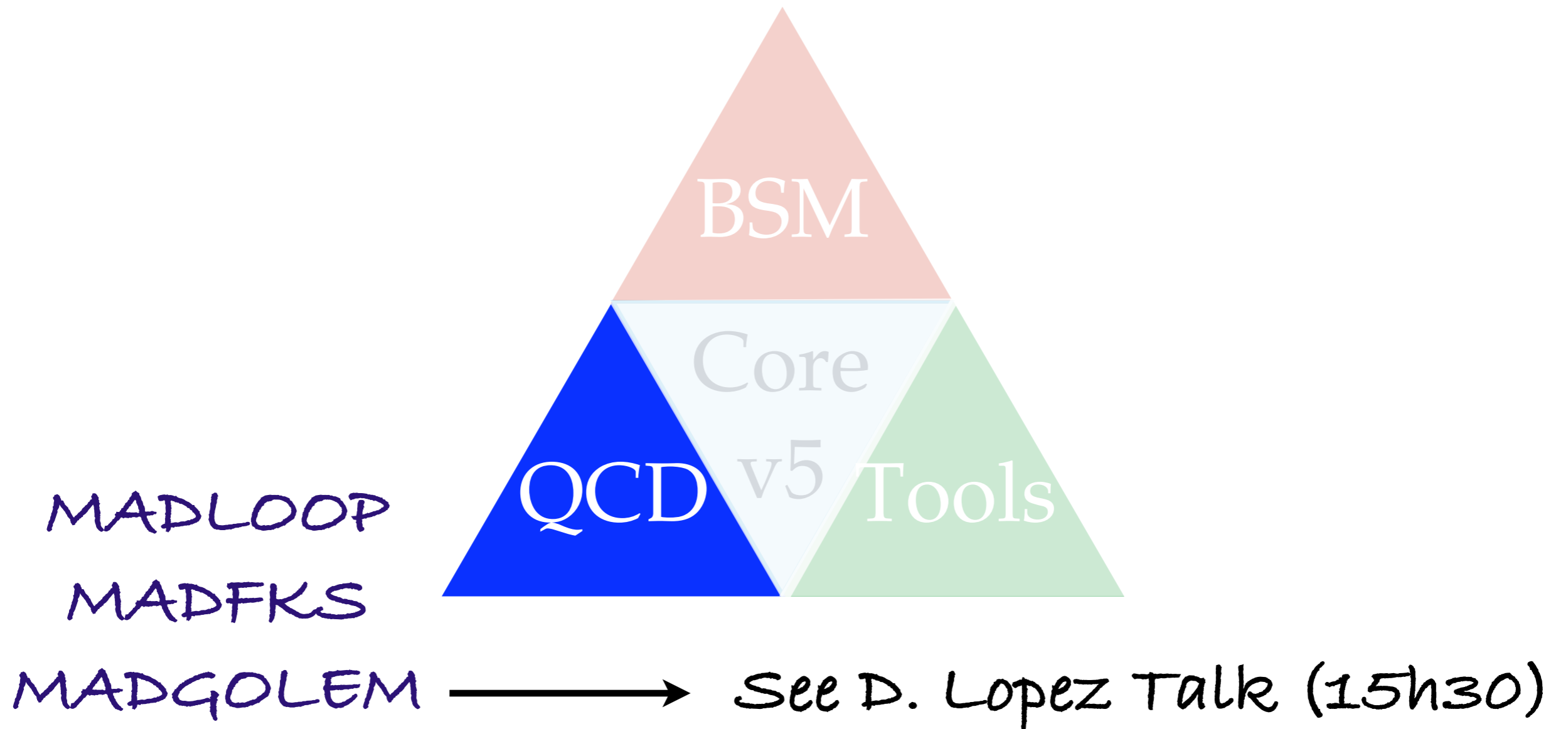
NLO   Virtual   Real   Born
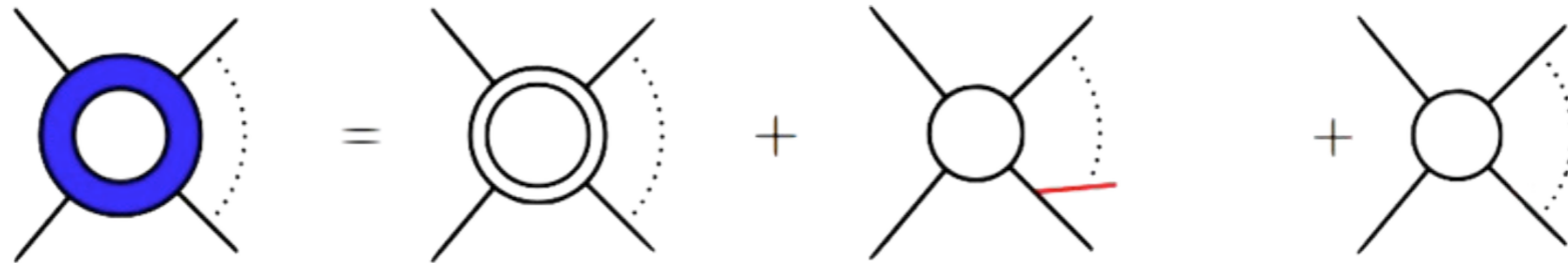
$$\sigma^{\mathrm{NLO}} = \int_m d^{(d)}\sigma^V + \int_{m+1} d^{(d)}\sigma^R + \int_m d^{(4)}\sigma^B$$

aMC@NLO = MadLoop + MadFKS + MadGraph

Parton shower →

Born+Virtual:

Real emission:

$$\frac{d\sigma_{\mathrm{MC@NLO}}}{dO} = \left[d\Phi_m\left(B + V + \int d\Phi_1 MC\right) \right]\mathcal{F}^{(m)}_{\mathrm{MC}}$$

MadLoop
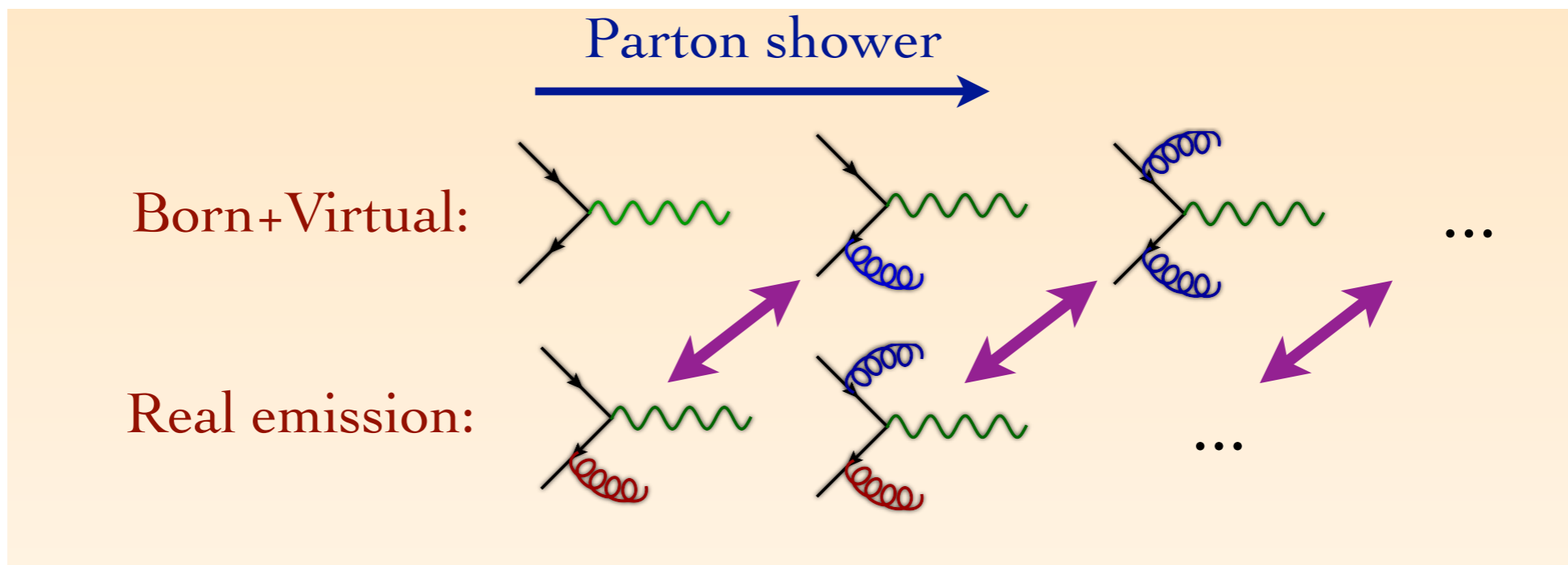
☐ Cuttools / OPP
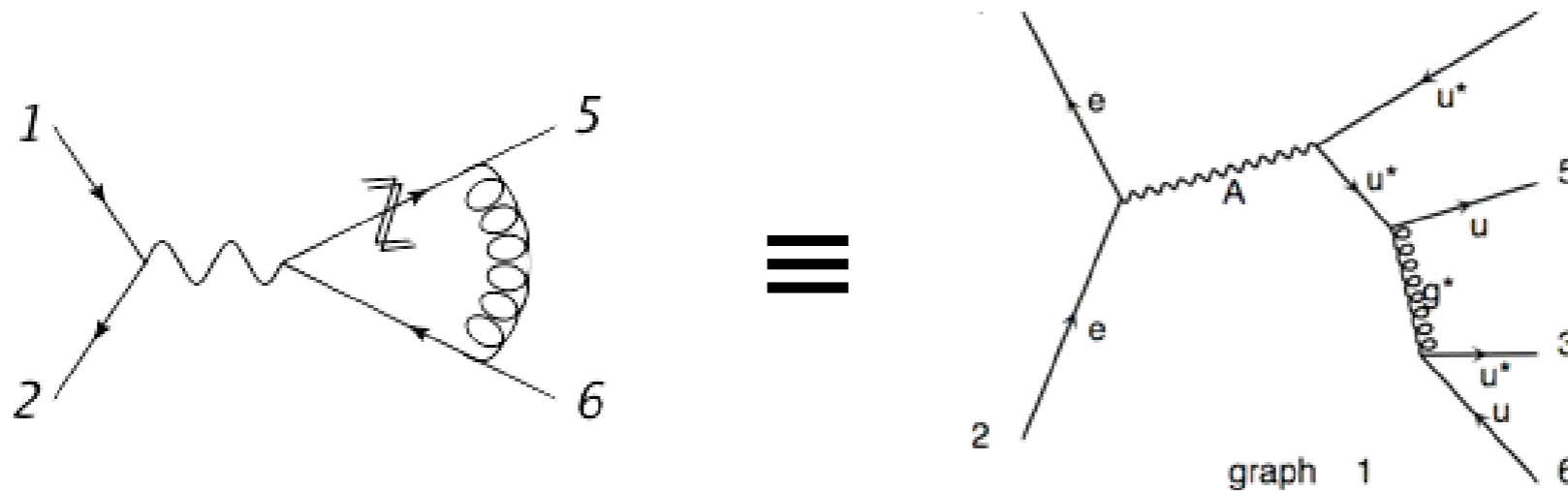
Process	Generation time[1]		Output size[2]		Compilation time[3]		Running time[4]	
d d~ > u u~	**8.750 s**	**5.378 s**	200 Kb	268 Kb	0.931 s	2.996 s	0.0088 s	0.0094 s
d d~ > d d~ g	**17.04 s**	**104.8 s**	124 Kb	1.7 Mb	4.799 s	19.181 s	0.64 s	0.74 s
d d~ > d d~ u u~	**22.50 s**	**2094 s**	232 Kb	3.3 Mb	37.75 s	45.02 s	1.93 s	2.34 s
g g > g g g g	**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	✕	137 min	✕

[1] : Process generated retaining all contribution with massive top and bottom quarks.   MadLoop5 = ♦
[2] : Of the equivalent `matrix.f` file.   [4] : Per PS points, Color/Helicity summed.   MadLoop4 = ♦

AMC@NLO in MadGraph 5

- 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)
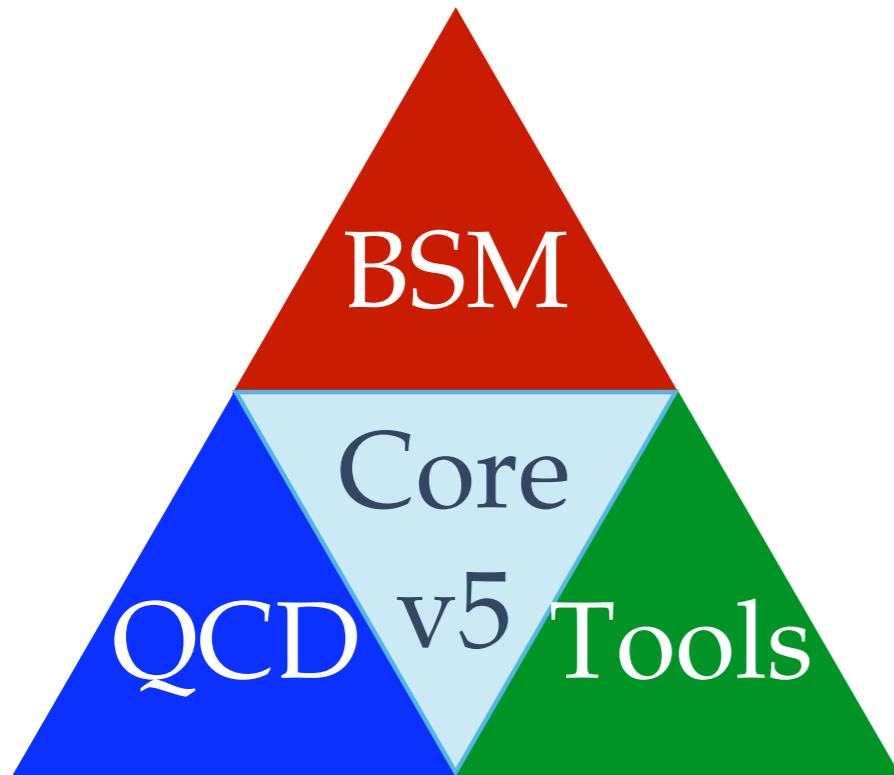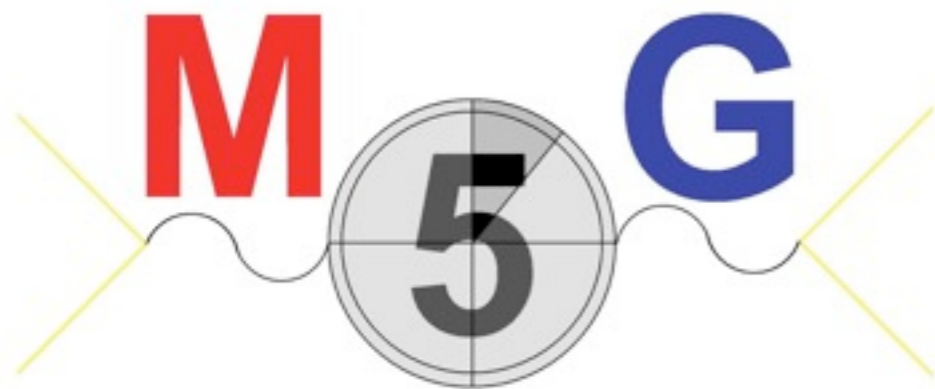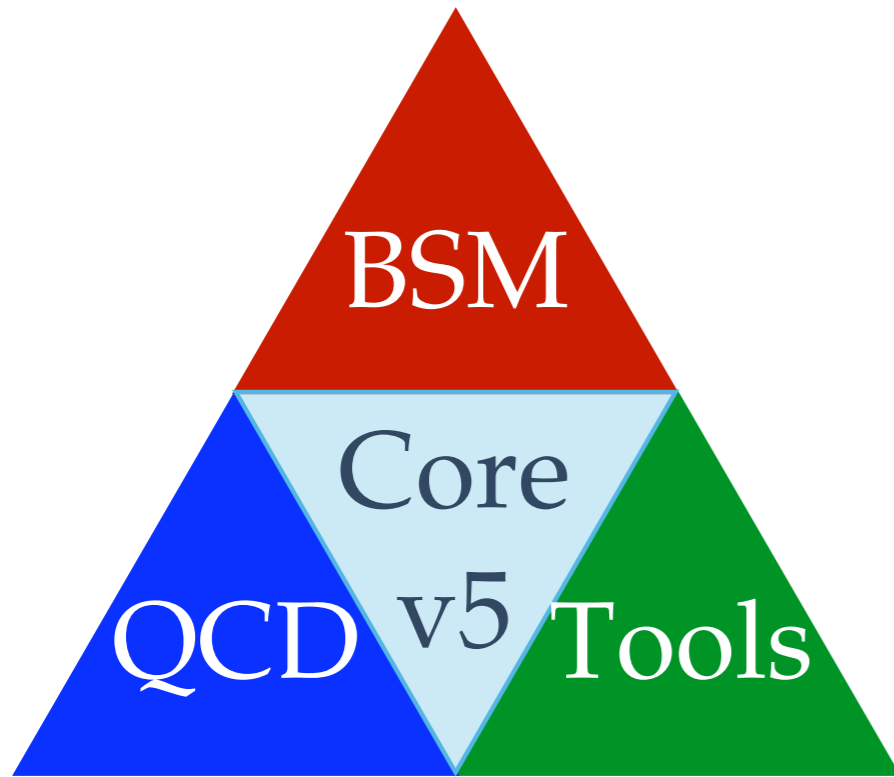
BSM

Core
v5

QCD Tools

https://launchpad.net/madgraph5

- MG5 is available on the web
- Big improvement compare to MG4

https://launchpad.net/madgraph5

BSM

Core
v5

QCD   Tools

M 5 G

- ☐ 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

Conclusion

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

https://launchpad.net/madgraph5

Conclusion
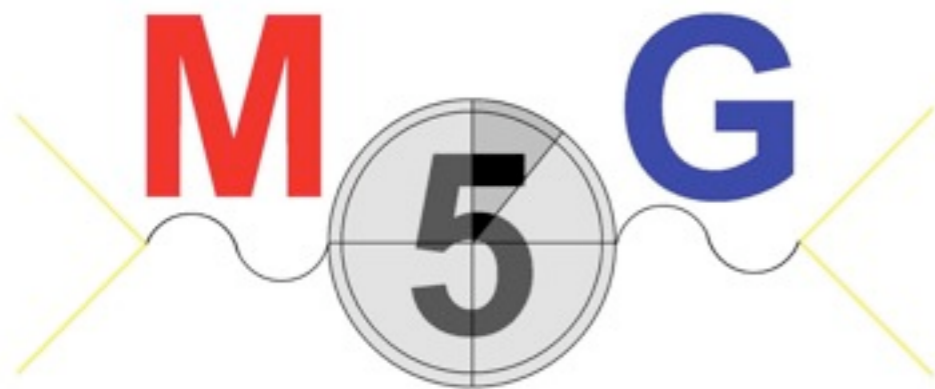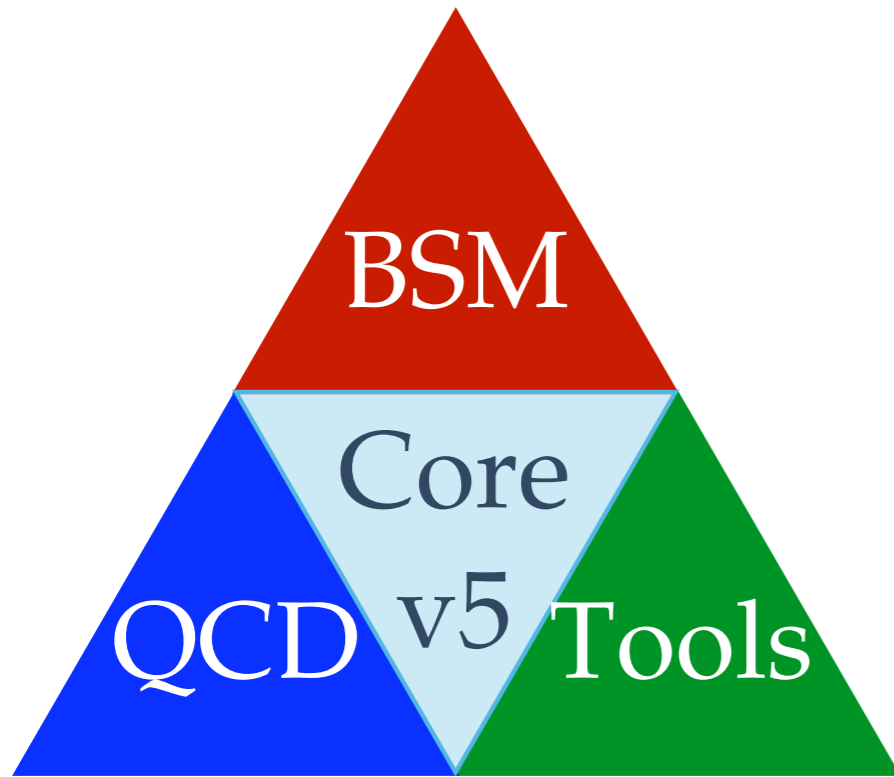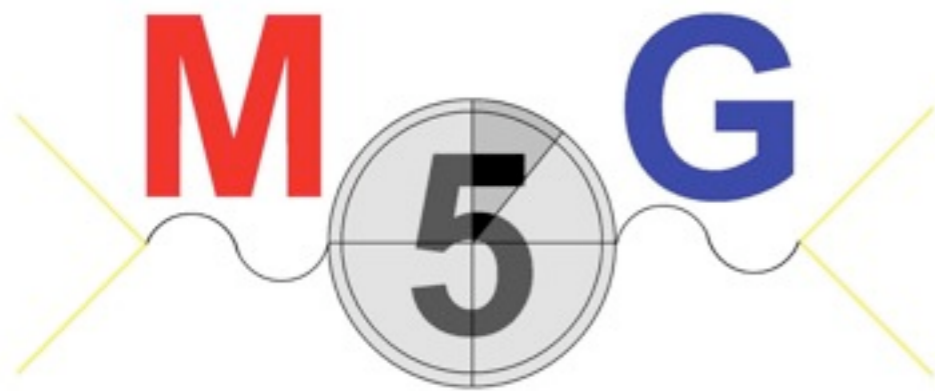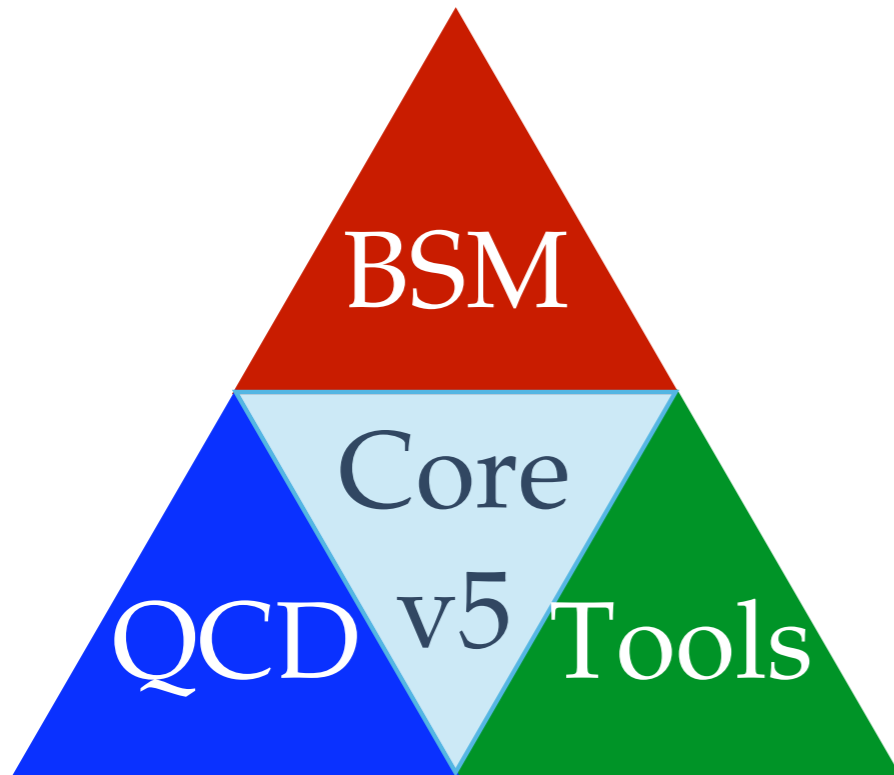
- MG5 is available on the web
- Big improvement compare to MG4
- Any BSM theory can be runned in MG5 in a fully automatic way
- Various tools available to help the community
- Large work to have a Fully automatic NLO generator

https://launchpad.net/madgraph5
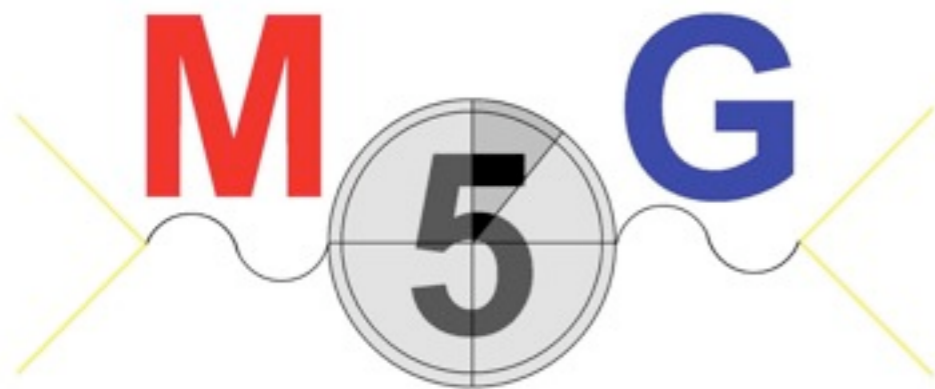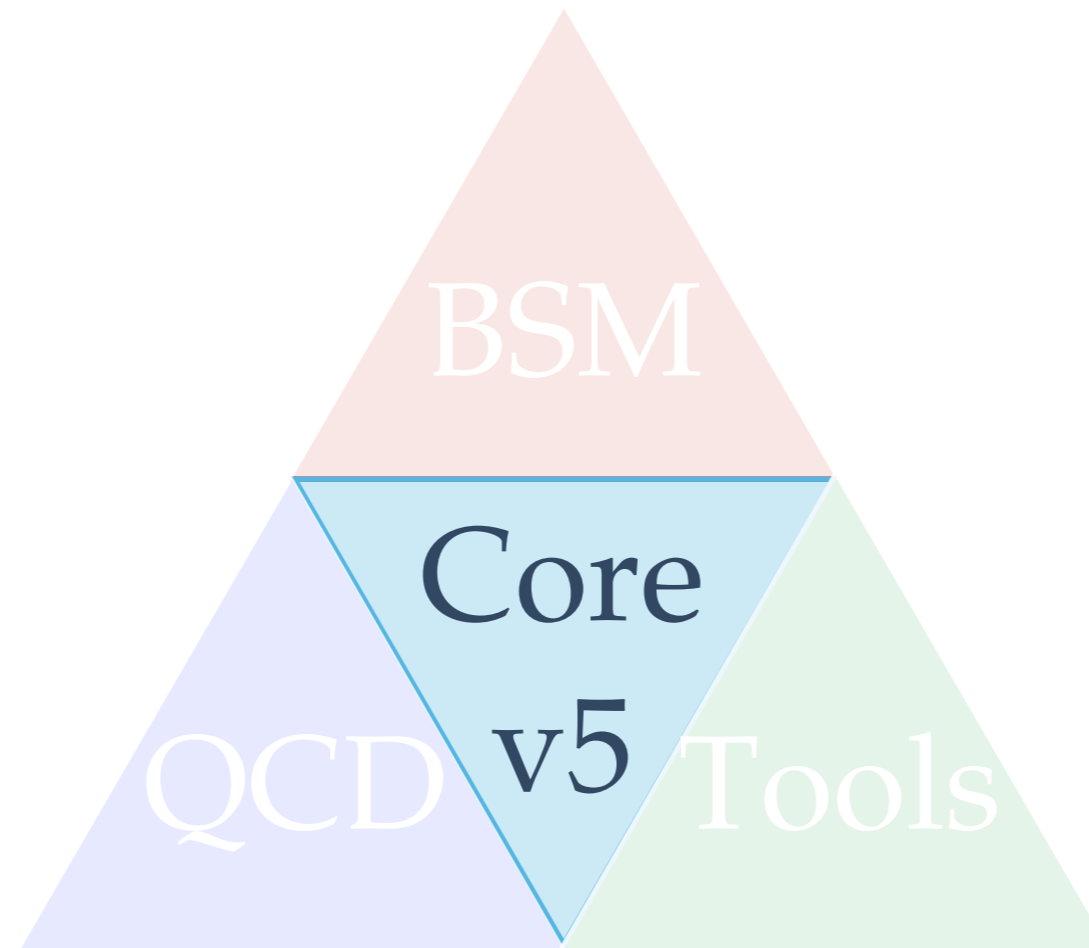
☐ mg5> compute_widths Z

    ☐ 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
    - ...

□ Inclusion of new output
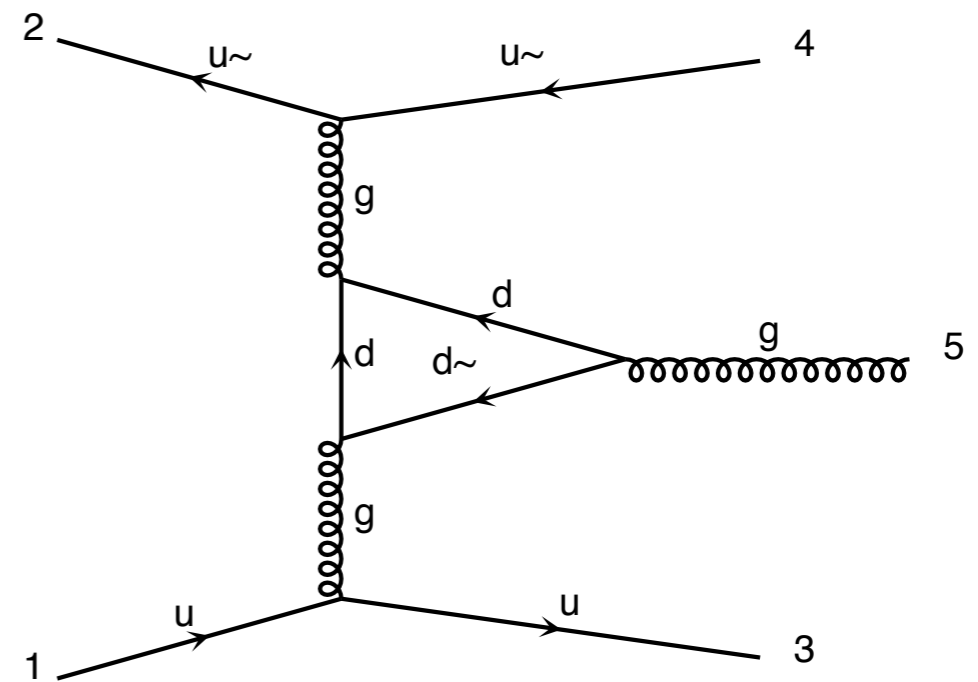
    □ MadDarkMatter

    □ MadWeight

    □ ...

□ MadLoop / aMC@NLO

diagram 19   QCD=5

And After...

- Inclusion of new output
  - MadDarkMatter
  - MadWeight
  - ...
- MadLoop / aMC@NLO
- usermod for UFO model
- MadAnalysis5

diagram 19   QCD=5

And After...
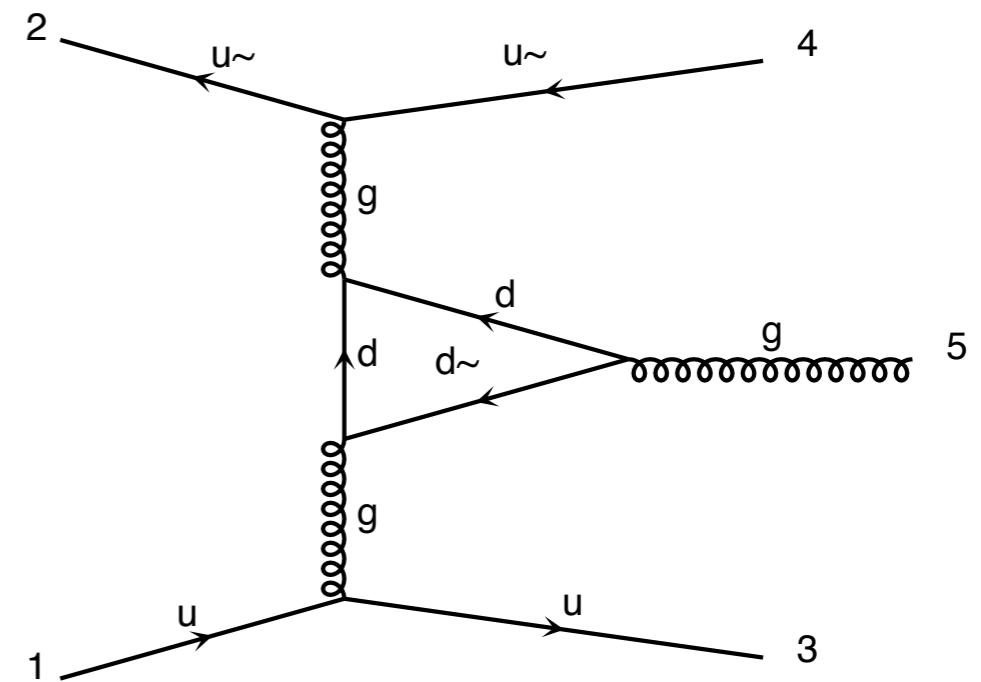
- ☐ Inclusion of new output
  - ☐ MadDarkMatter
  - ☐ MadWeight
  - ☐ ...
- ☐ MadLoop / aMC@NLO
- ☐ usermod for UFO model
- ☐ MadAnalysis5
- ☐ color ordered amplitude

diagram 19   QCD=5

And After...
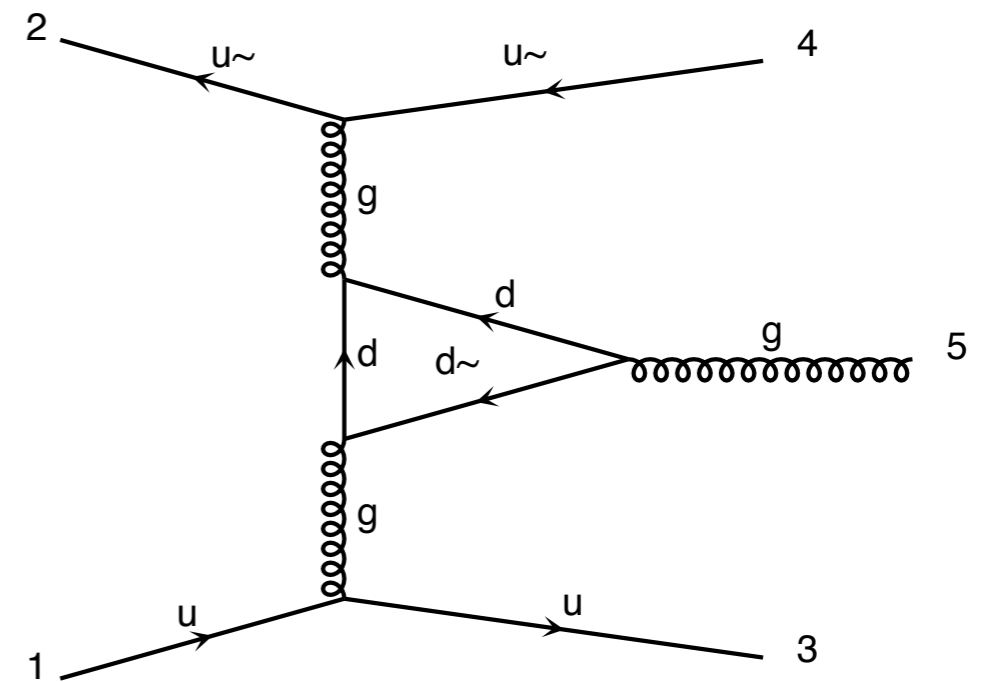
- Inclusion of new output
  - MadDarkMatter
  - MadWeight
  - ...
- MadLoop / aMC@NLO
- usermod for UFO model
- MadAnalysis5
- color ordered amplitude
- recursion relations

diagram 19   QCD=5

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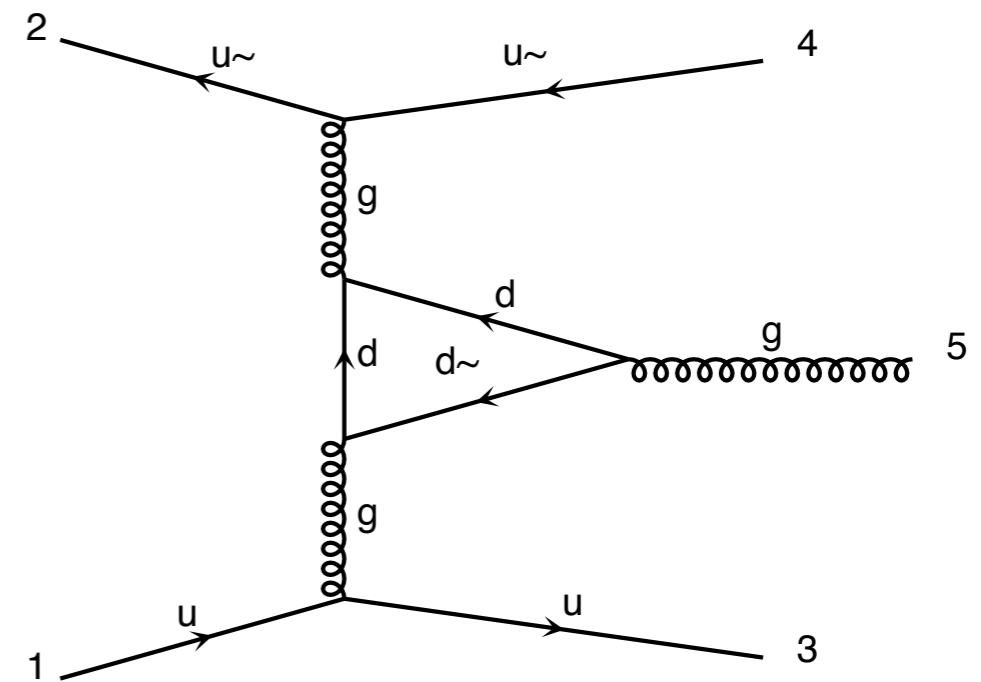
- Inclusion of new output
  - MadDarkMatter
  - MadWeight
  - ...
- MadLoop / aMC@NLO
- usermod for UFO model
- MadAnalysis5
- color ordered amplitude
- recursion relations
- computing the widths

diagram 19   QCD=5

Speed
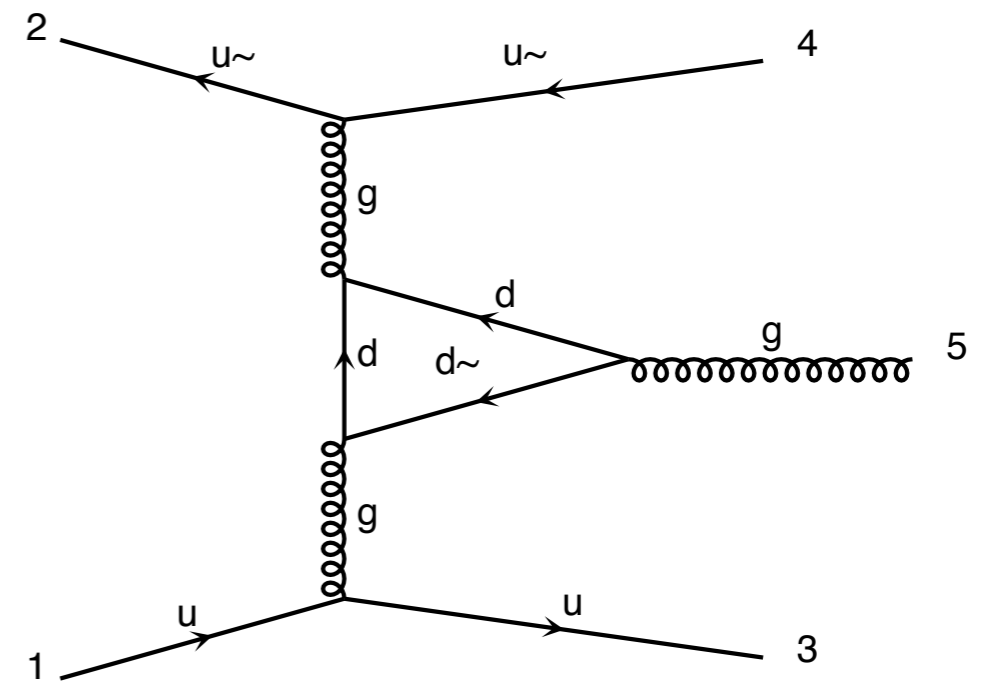
Matrix Element generation:

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

Matrix Element evaluation (Fortran):

Process	Function calls MG 4	Function calls MG 5	Run time MG 4	Run time MG 5
$u\bar{u} \to e^+e^-$	8	8	$< 6\mu s$	$< 6\mu s$
$u\bar{u} \to e^+e^-e^+e^-$	110	80	0.22 ms	0.14 ms
$u\bar{u} \to e^+e^-e^+e^-e^+e^-$	6668	3775	46.5 ms	19.0 ms
$u\bar{u} \to d\bar{d}$	6	6	$< 4\mu s$	$< 4\mu s$
$u\bar{u} \to d\bar{d}g$	16	16	27 μs	27 μs
$u\bar{u} \to d\bar{d}gg$	85	67	0.42 ms	0.31 ms
$u\bar{u} \to d\bar{d}ggg$	748	515	10.8 ms	6.75 ms
$u\bar{u} \to u\bar{u}gg$	160	116	1.24 ms	0.80 ms
$u\bar{u} \to u\bar{u}ggg$	1468	960	35.7 ms	17.2 ms
$u\bar{u} \to d\bar{d}d\bar{d}$	42	33	84 μs	83 μs
$u\bar{u} \to d\bar{d}d\bar{d}g$	310	197	1.88 ms	1.15 ms
$u\bar{u} \to d\bar{d}d\bar{d}gg$	3372	1876	141 ms	34.4 ms

Johan Alwall - The Vision of MG/FR

Mattelaer Olivier · PHENO 2012 : MadGraph 5 · 26

```
**********************************************************************
*                                                                    *
*          W E L C O M E  to  M A D G R A P H  5                     *
*                                                                    *
*                                                                    *
*                  *                        *                        *
*                    *          * *          *                       *
*                      * * * * 5 * * * *                             *
*                    *          * *          *                       *
*                  *                        *                        *
*                                                                    *
*          VERSION 1.3.16                2011-09-11                   *
*                                                                    *
*    The MadGraph Development Team - Please visit us at               *
*    https://server06.fynu.ucl.ac.be/projects/madgraph               *
*                                                                    *
*              Type 'help' for in-line help.                         *
*              Type 'tutorial' to learn how MG5 works                *
*                                                                    *
**********************************************************************
load MG5 configuration from /Users/omatt/.mg5_config
Loading default model: sm
models.import_ufo: Restrict model sm with file models/sm/rest
models.import_ufo: Run "set stdout_level DEBUG" before import
INFO: Change particles name to pass to MG5 convention
Defined multiparticle p = g u c d s u~ c~ d~ s~
Defined multiparticle j = g u c d s u~ c~ d~ s~
Defined multiparticle l+ = e+ mu+
Defined multiparticle l- = e- mu-
Defined multiparticle vl = ve vm vt
Defined multiparticle vl~ = ve~ vm~ vt~
mg5>help
```

☐ Nice Interactive session

```
*********************************************************
*                                                       *
*           W E L C O M E  to  M A D G R A P H  5       *
*                                                       *
*                                                       *
*                  *                       *            *
*                   *        * *         *              *
*                     * * * * 5 * * * *                 *
*                   *        * *         *              *
*                  *                       *            *
*                                                       *
*           VERSION 1.3.16              2011-09-11       *
*                                                       *
*     The MadGraph Development Team - Please visit us at *
*     https://server06.fynu.ucl.ac.be/projects/madgraph *
*                                                       *
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*              Type 'tutorial' to learn how MG5 works    *
*                                                       *
*********************************************************
load MG5 configuration from /Users/omatt/.mg5_config
Loading default model: sm
models.import_ufo: Restrict model sm with file models/sm/rest
models.import_ufo: Run "set stdout_level DEBUG" before import
INFO: Change particles name to pass to MG5 convention
Defined multiparticle p = g u c d s u~ c~ d~ s~
Defined multiparticle j = g u c d s u~ c~ d~ s~
Defined multiparticle l+ = e+ mu+
Defined multiparticle l- = e- mu-
Defined multiparticle vl = ve vm vt
Defined multiparticle vl~ = ve~ vm~ vt~
mg5>help
```

- Nice **Interactive** session

  - Auto-completion

```
********************************************************************
*                                                                  *
*          W E L C O M E  to  M A D G R A P H  5                   *
*                                                                  *
*                                                                  *
*                 *                         *                      *
*                   *        * *        *                          *
*                     * * * * 5 * * * *                            *
*                   *        * *        *                          *
*                 *                         *                      *
*                                                                  *
*          VERSION 1.3.16              2011-09-11                   *
*                                                                  *
*   The MadGraph Development Team – Please visit us at             *
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*                                                                  *
*                Type 'help' for in-line help.                     *
*                Type 'tutorial' to learn how MG5 works            *
*                                                                  *
********************************************************************
load MG5 configuration from /Users/omatt/.mg5_config
Loading default model: sm
models.import_ufo: Restrict model sm with file models/sm/rest
models.import_ufo: Run "set stdout_level DEBUG" before import
INFO: Change particles name to pass to MG5 convention
Defined multiparticle p = g u c d s u~ c~ d~ s~
Defined multiparticle j = g u c d s u~ c~ d~ s~
Defined multiparticle l+ = e+ mu+
Defined multiparticle l- = e- mu-
Defined multiparticle vl = ve vm vt
Defined multiparticle vl~ = ve~ vm~ vt~
mg5>help
```

- Nice **Interactive** session
  - Auto-completion
  - Tutorial

```
******************************************************
*                                                    *
*        W E L C O M E  to  M A D G R A P H  5       *
*                                                    *
*                                                    *
*                 *                      *           *
*                   *        * *        *            *
*                     * * * * 5 * * * *              *
*                   *        * *        *            *
*                 *                      *           *
*                                                    *
*          VERSION 1.3.16          2011-09-11        *
*                                                    *
*    The MadGraph Development Team - Please visit us at *
*    https://server06.fynu.ucl.ac.be/projects/madgraph *
*                                                    *
*              Type 'help' for in-line help.         *
*              Type 'tutorial' to learn how MG5 works *
*                                                    *
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Defined multiparticle j = g u c d s u~ c~ d~ s~
Defined multiparticle l+ = e+ mu+
Defined multiparticle l- = e- mu-
Defined multiparticle vl = ve vm vt
Defined multiparticle vl~ = ve~ vm~ vt~
mg5>help
```

Command Interface

- Nice Interactive session

  - Auto-completion

  - Tutorial

  - interactive help

```
*********************************************************
*                                                       *
*          W E L C O M E  to  M A D G R A P H  5        *
*                                                       *
*                    *                   *              *
*              *         * *  *        *                *
*              * * * * 5 * * * *                        *
*                *          * *       *                 *
*                    *                *                 *
*                                                       *
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mg5>help
```

Command Interface

- Nice Interactive session
  - Auto-completion
  - Tutorial
  - interactive help

If You test it, you are going to like it !

```
*********************************************************
*                                                       *
*       W E L C O M E  to  M A D G R A P H  5           *
*                                                       *
*                  *                    *               *
*              *       * *         *                    *
*           * * * * 5 * * * *                           *
*              *       * *         *                    *
*                  *                    *               *
*                                                       *
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- Nice Interactive session
  - Auto-completion
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```
****************************************************************

*                                                              *
*          W E L C O M E  to  M A D G R A P H  5              *
*                                                              *
*                    *                      *                  *
*                 *       *          * *          *            *
*              * * * * 5 * * * *                               *
*                 *       *          * *          *            *
*                    *                      *                  *
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Command Interface

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  - interactive help

- Simple command set

```
******************************************************************
*                                                                *
*        W E L C O M E  to  M A D G R A P H  5                   *
*                                                                *
*                   *                      *                     *
*                *        *    **       *                        *
*              * * * * 5 * * * *                                 *
*                *        * *    *                               *
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Command Interface

- Nice **Interactive** session

  - Auto-completion

  - Tutorial

  - interactive help

- Simple command set

  - import model sm

  - generate p p > e+ e-

  - output FORMAT MY_DIR

  - launch

```
****************************************************
*                                                  *
*      W E L C O M E  to  M A D G R A P H  5       *
*                                                  *
*                 *          *                      *
*             *       * *       *                   *
*           * * * * 5 * * * *                       *
*             *       * *       *                   *
*                 *          *                      *
*                                                  *
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mg5>help
```

Output

☐ MadEvent (Fortran)

☐ Standalone (Fortran)

☐ Standalone(C++) ⟵ NEW

☐ Pythia 8 (C++) ⟵ NEW

Compact and optimise output for MadEvent

Process	Subprocess directories		Channels for survey		Directory size	
	ME 4	ME 5	ME 4	ME 5	ME 4	ME 5
$pp \to W^+ j$	6	2	12	4	79 MB	35 MB
$pp \to W^+ jj$	41	4	138	29	438 MB	64 MB
$pp \to W^+ jjj$	73	5	1164	184	842 MB	110 MB
$pp \to W^+ jjjj$	296	7	15029	1327	3.8 GB	352 MB
$pp \to l^+ l^- j$	12	2	48	8	149 MB	44 MB
$pp \to l^+ l^- jj$	54	4	586	58	612 MB	83 MB
$pp \to l^+ l^- jjj$	86	5	5408	368	1.2 GB	151 MB
$pp \to l^+ l^- jjjj$	235	7	63114	2500	5.3 GB	662MB
$pp \to t\bar{t}$	3	2	5	4	49 MB	39 MB
$pp \to t\bar{t}j$	7	3	45	25	97 MB	56 MB
$pp \to t\bar{t}jj$	22	5	417	188	274 MB	98 MB
$pp \to t\bar{t}jjj$	34	6	3816	1300	620 MB	209 MB

After the initial Goal?

Current 1.4.3

1.4.0

Current 1.4.3

Not possible to detail everything

1.4.0

What's new

□ 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

What's new

☐ Improve Phase-space integration

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```
mg5>display coupling_order
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 QED : weight = 2
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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

What's new

☐ Check that the param_card is compatible with the model

☐ MSSM will support SLAH1 card

What's new

☐ Check that the param_card is compatible with the model

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☐ Improve user interface

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☐ configuration files

- Check that the param_card is compatible with the model

- MSSM will support SLAH1 card

- Improve user interface

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  - New interface for madevent

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    ☐ Easy to install pythia-pgs/Delphes/...

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☐ Check that the param_card is compatible with the model

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☐ Possibility to compute partial width (and BR)

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- ☐ Check that the param_card is compatible with the model

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- ☐ Improving the gridpack

What's new

□ 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/...

□ Possibility to compute partial width (and BR)

□ Improving the gridpack

□ add a cut forbidding on-shell particles but allowing off-sheel contribution ($)

$$pp > e+ \, e- \, \$\$ \, Z$$
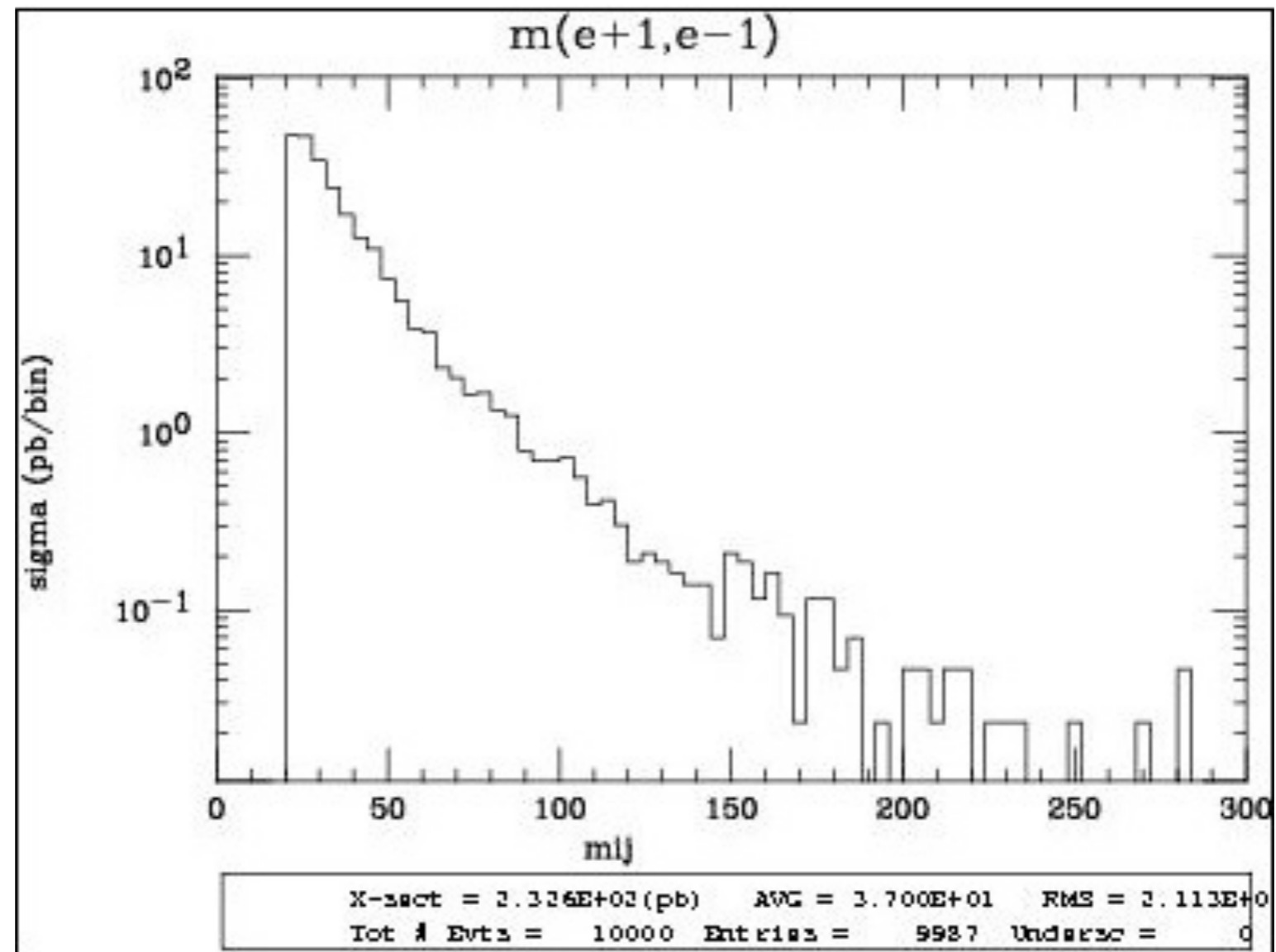
$$p\,p > e+\ e- \$\$\ Z$$
$$p\,p > e+\ e- \$\ Z$$

BW cutt =5
(small for the
example)
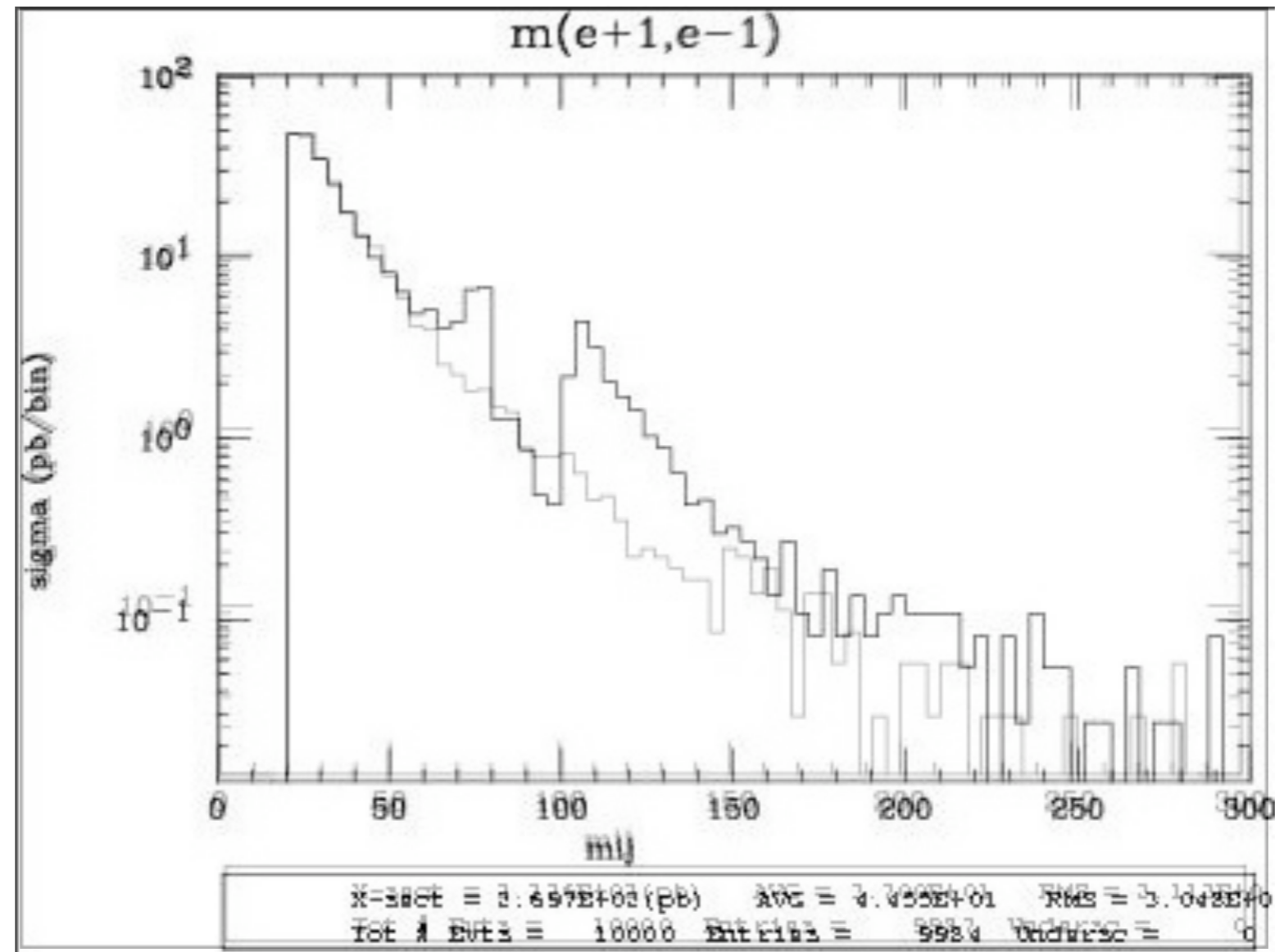
$p\,p > e+\ e-\ \$\$\ Z$

$p\,p > e+\ e-\ \$\ Z$

Z- onshell veto

BW cutt =5 (small for the example)

$$p\,p > e+\ e-\,\$\$\,Z$$
$$p\,p > e+\ e-\,\$\,Z$$

Z- onshell veto

BW cutt =5 (small for the example)

m(e+1,e-1)
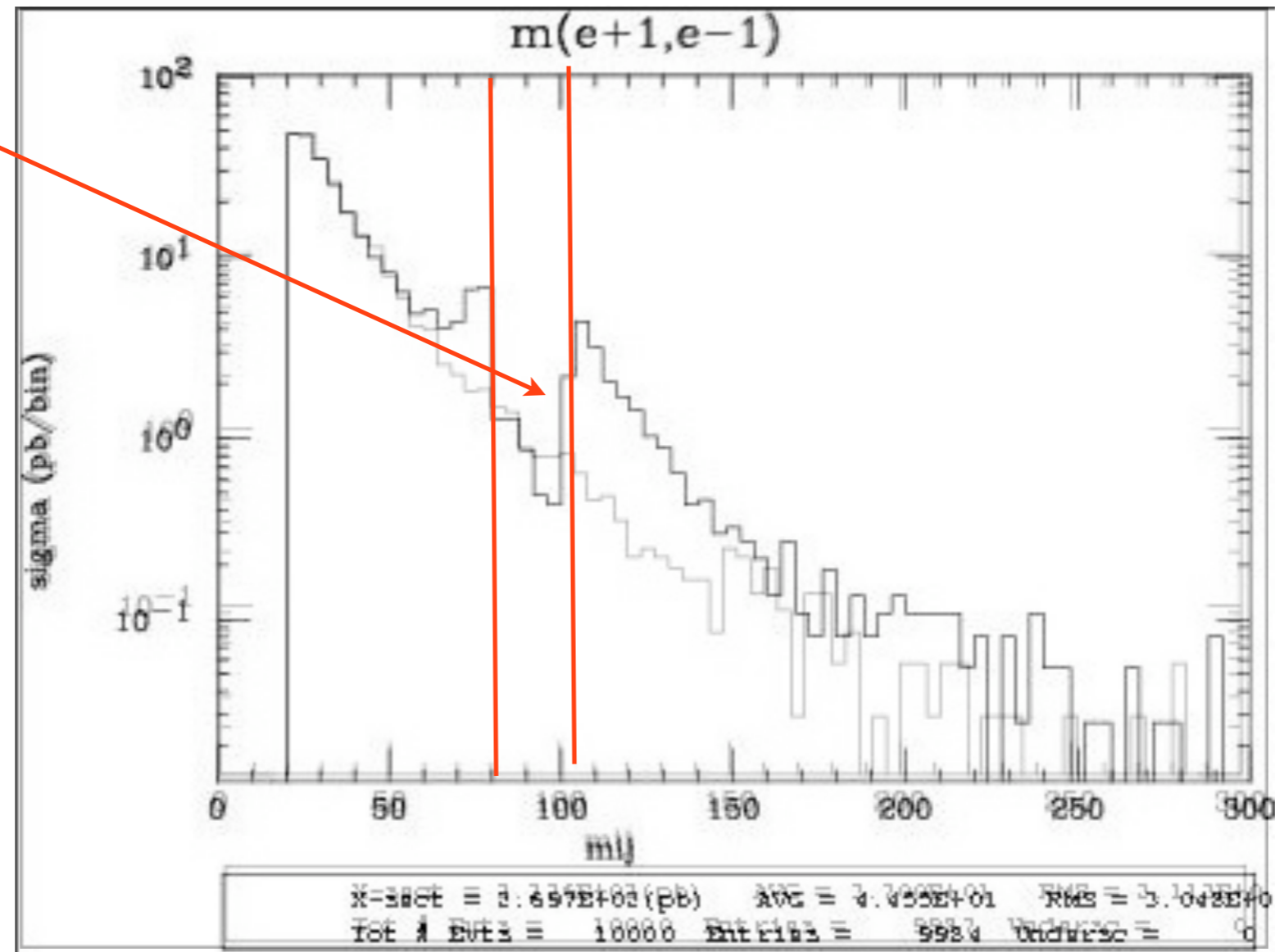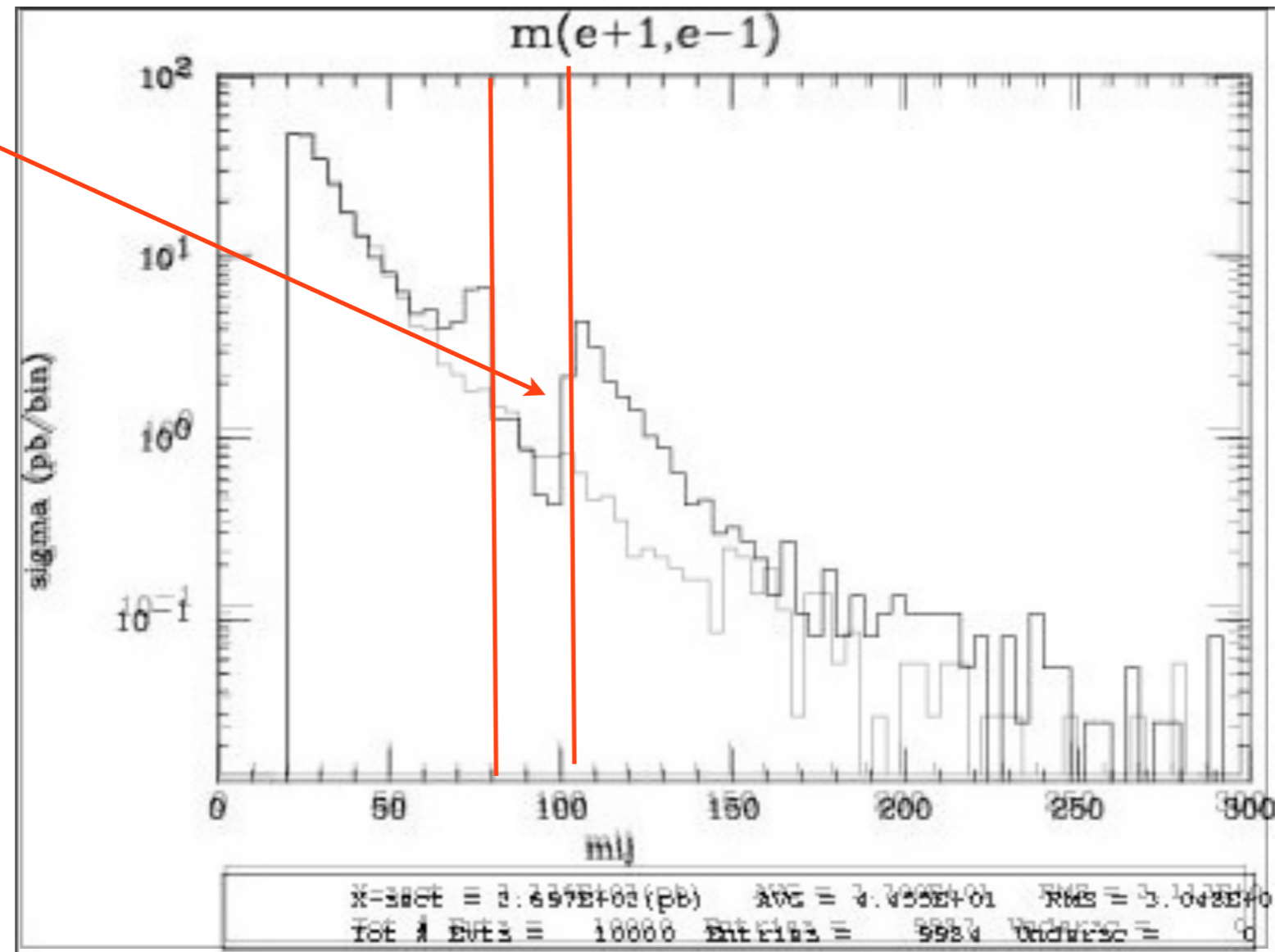
Offshell Z interference is BG

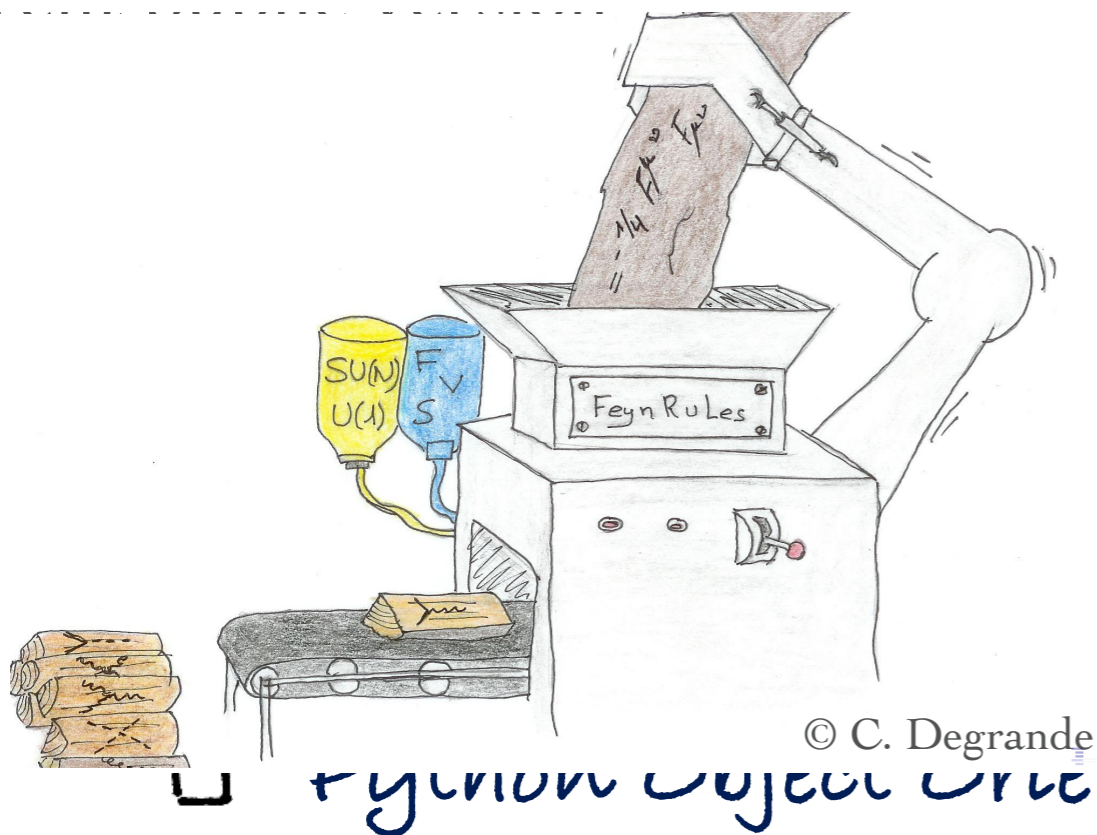UFO / ALOHA
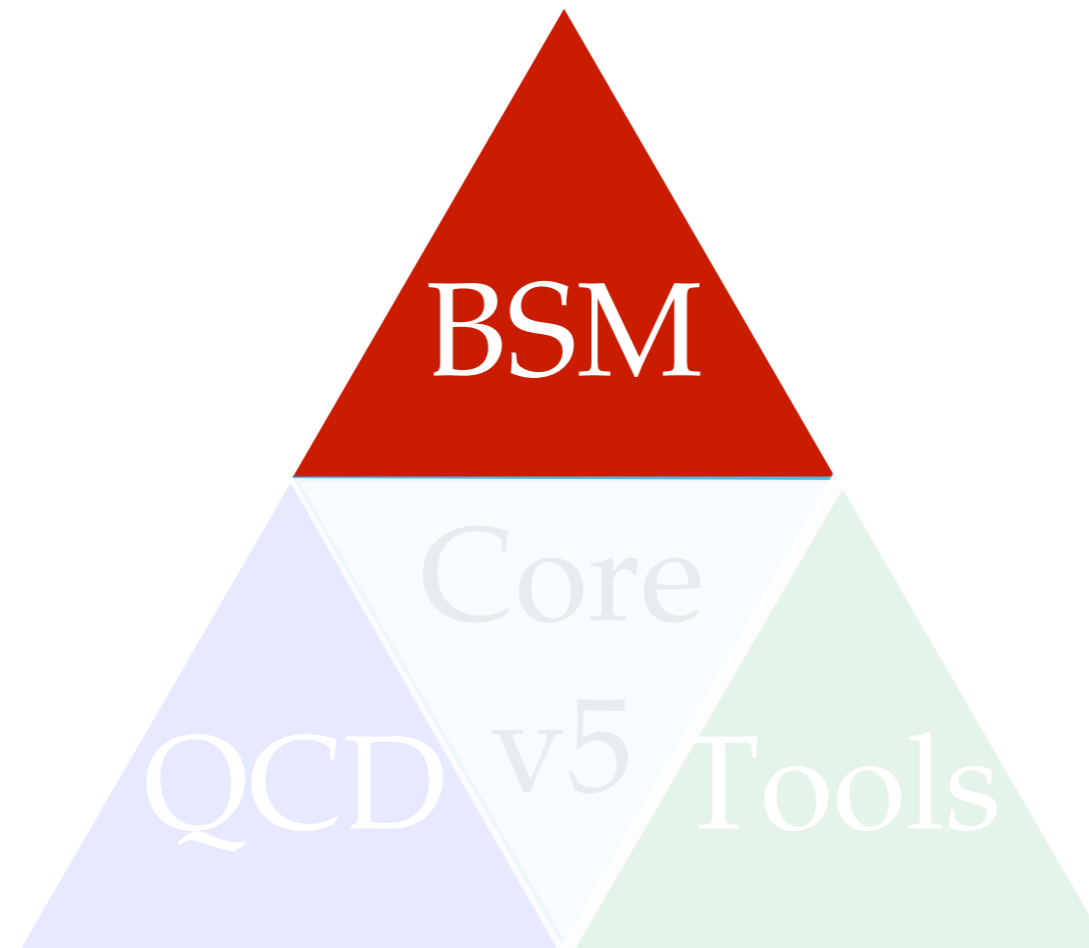
☐ Avoid multiple output model written by FR.

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

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☐ Avoid any possible limitations
- ☐ color
- ☐ lorentz structure
- ☐ number of particles in a vertex
- ☐ gauge

UFO: Motivations

☐ Avoid multiple output model written by FR.

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  - ☐ color
  - ☐ lorentz structure
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☐ Joint model for MG5 / GOSAM / Herwig++

UFO: Motivations

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    - color
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    - number of particles in a vertex
    - gauge
- Joint model for MG5 / GOSAM / Herwig++
- Python Object Oriented Model

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

limitations

e

les in a vertex

5 / GOSAM / Herwig++

Python Object Oriented Model

© C. Degrande

☐ Avoid multiple output model written by FR.

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☐ Avoid any possible limitations

- ☐ color
- ☐ lorentz structure
- ☐ number of particles in a vertex
- ☐ gauge

☐ Joint model for MG5 / GOSAM / Herwig++

☐ Python Object Oriented Model

FORMAT
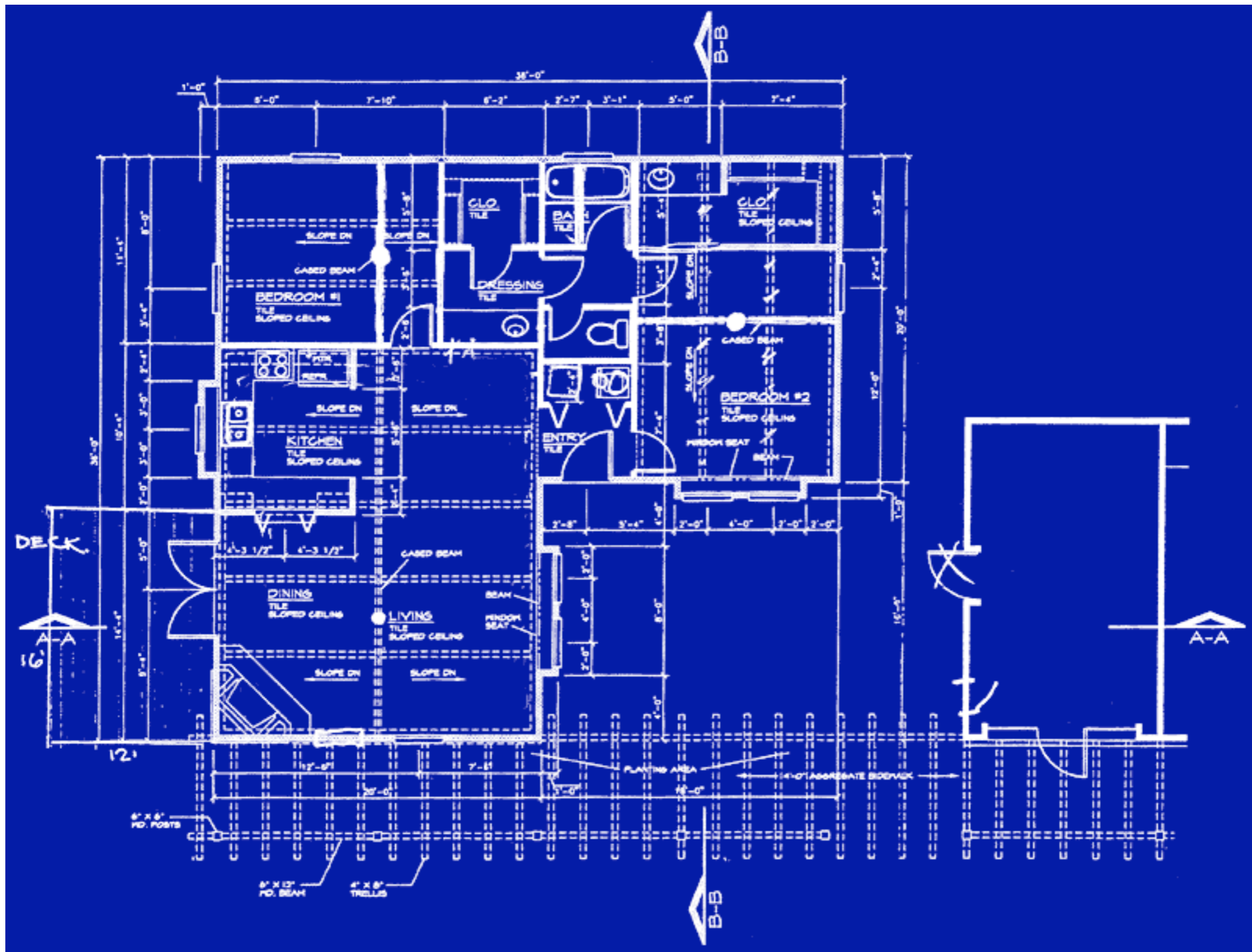
Universal FeynRules Output (UFO)

particles.py:

```
G = Particle(pdg_code = 21,
        name = 'G',
        antiname = 'G',
        spin = 3,
        color = 8,
        mass = 'ZERO',
        width = 'ZERO',
        texname = 'G',
        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:

```
V_2 = Vertex(name = 'V_2',
        particles = [ P.G, P.G, P.G ],
        color = [ 'f(1,2,3)' ],
        lorentz = [ L.VVV1 ],
        couplings = {(0,0):C.GC_4})
```

36

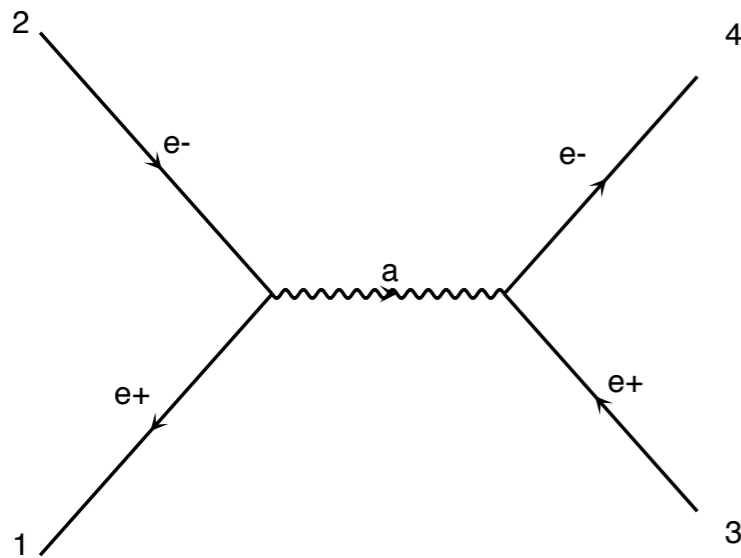☐ **Idea:** Evaluate m for fixed helicity of external particles.

diagram 1   QED=2

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

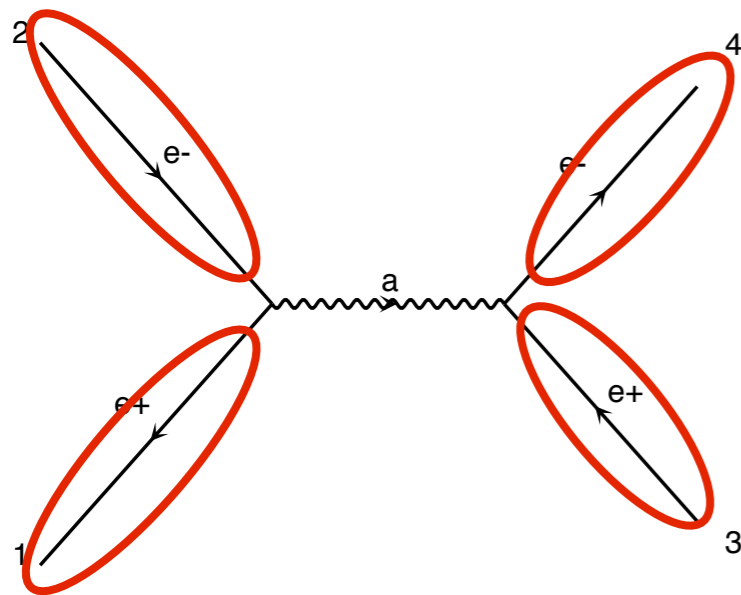☐ **Idea:** Evaluate m for fixed helicity of external particles.

diagram 1   QED=2

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

→ 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))
```

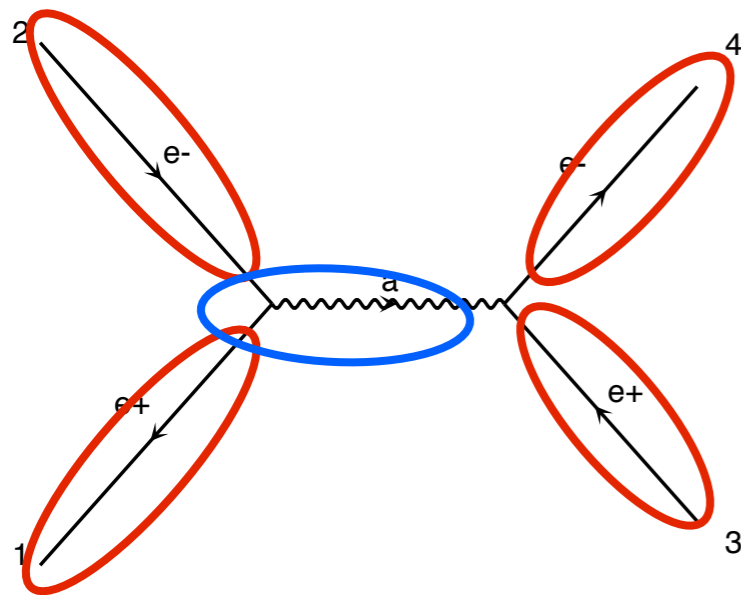□ **Idea:** Evaluate m for fixed helicity of external particles.

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➜ Number for a given helicity

➜ Evaluate interaction by interaction

```
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))
CALL JIOXXX(W(1,1),W(1,2),GG,ZERO,ZERO,W(1,5))
```

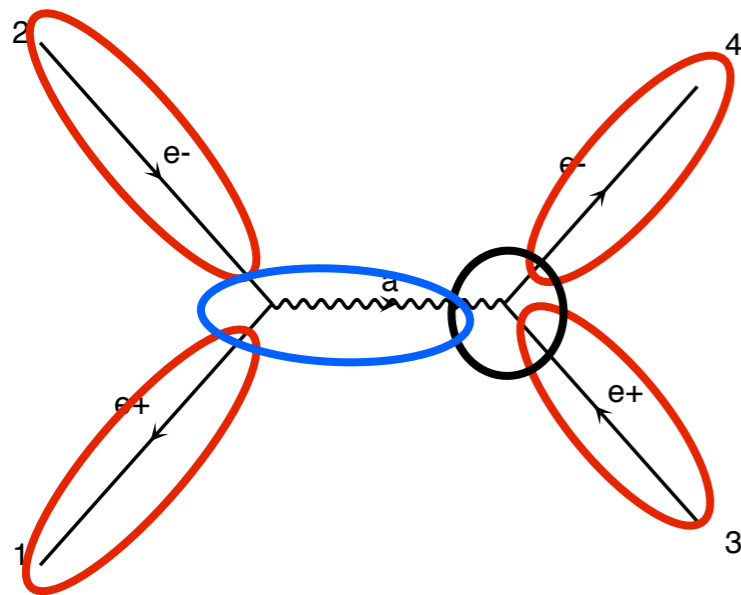☐ **Idea:** Evaluate m for fixed helicity of external particles.


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CALL IXXXXX(P(0,1),ZERO,NHEL(1),+1*IC(1),W(1,1))
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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))
CALL JIOXXX(W(1,1),W(1,2),GG,ZERO,ZERO,W(1,5))
CALL IOVXXX(W(1,4),W(1,3),W(1,5),GG,AMP(1))
```

- Speed:

Basics: Helicity amplitudes

- The complexity grows linearly with the number of diagram

- recycling between diagram (so reduces the factorial growth)
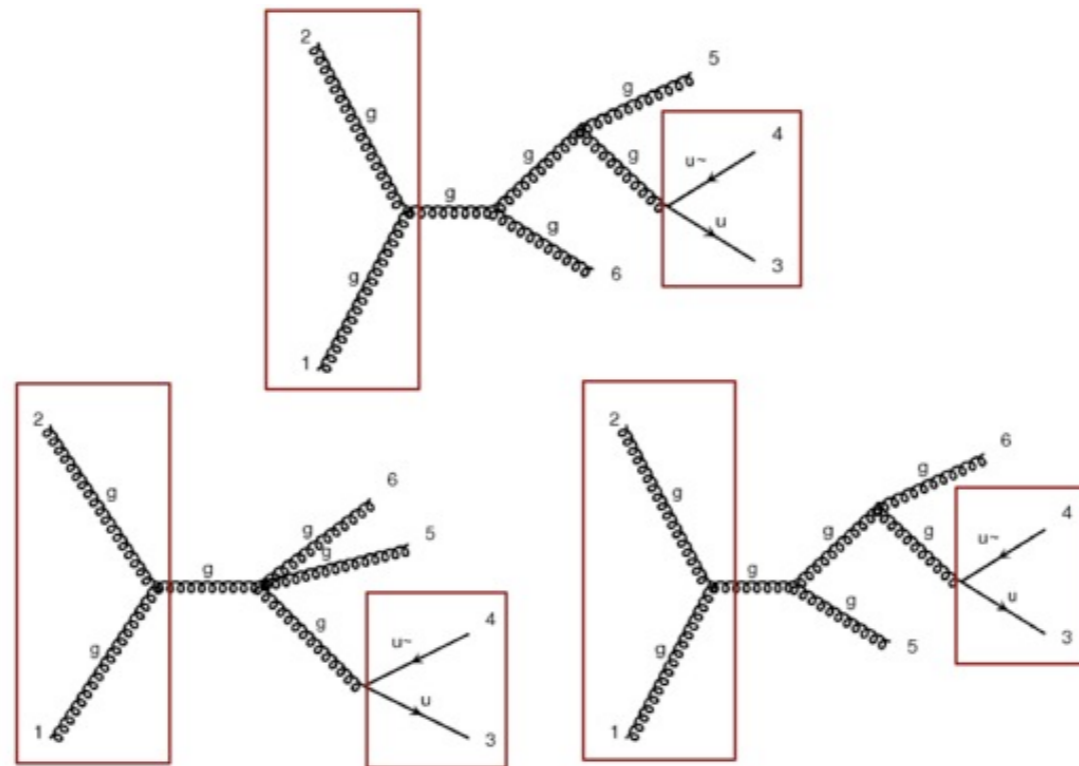
□ Spins of the particles

☐ Spins of the particles

☐ One routine by Lorentz structure

☐ Spins of the particles

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

Limitations

- Spins of the particles

- One routine by Lorentz structure

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

  - HEFT [Frederix] (2007)

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

Limitations

- Spins of the particles

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

    - HEFT [Frederix] (2007)

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

    - Spin 3/2 [Mawatari, al] 1101.1289 (2011)

DECAY

MADWEIGHT

MadAnalysis5

MadWeight
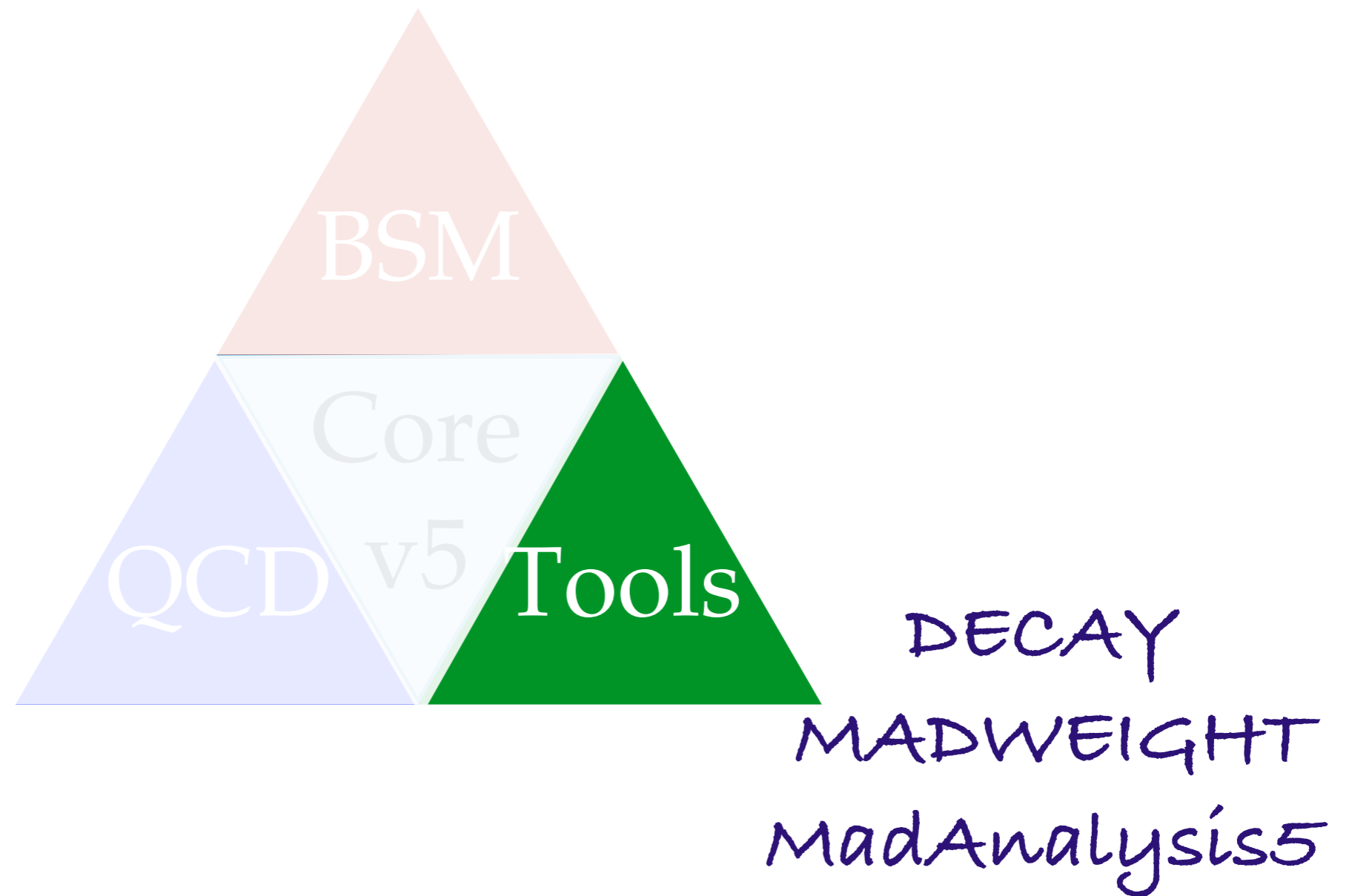
- ☐ Tools for the Matrix Element Method

- ☐ Reweighting based on the matrix-element

- ☐ Technique used for the top mass measurment

  Now Included in MG5 (still in beta)

- ☐ Include ISR corrections

- ☐ Better multi-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 multi-process treatment

☐ 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 level

No Phase-space
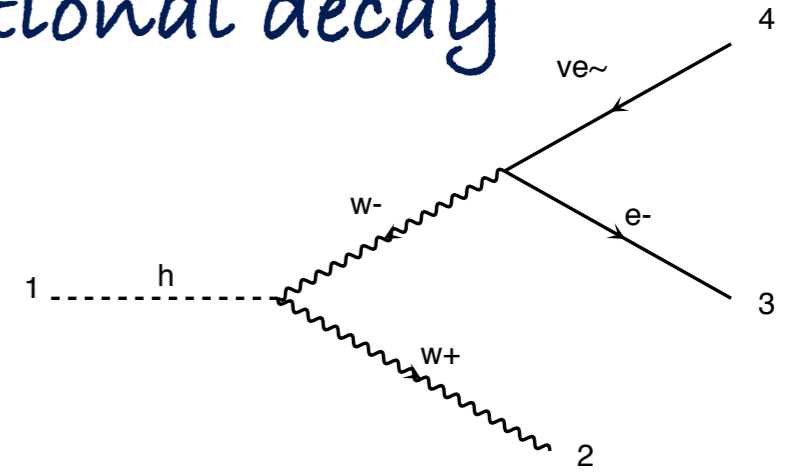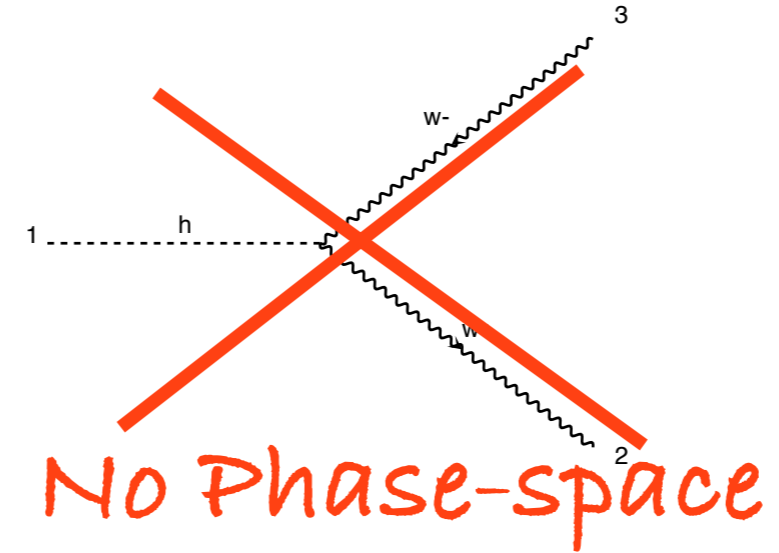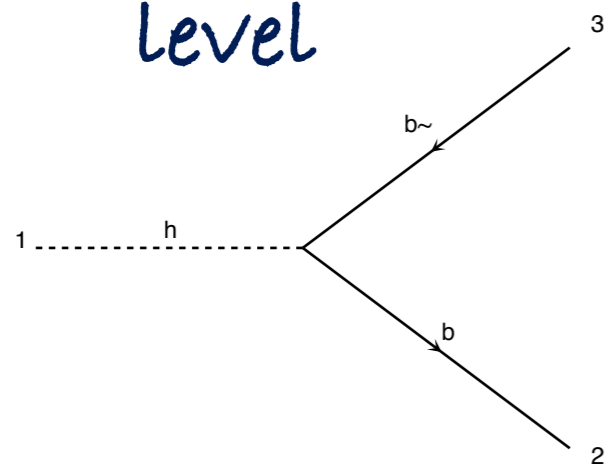
☐ Possibility to add a module for decaying the final state particles with either a part OR the full spin-correlation. For ANY BSM theories

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

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

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

- $|M_\alpha(\boldsymbol{p})|^2$ is the squared matrix element

- $W(\boldsymbol{p}, \boldsymbol{p}^{vis})$ is the transfer function

- $\int d\Phi \, dx_1 dx_2$ is the phase-space integral

- σ_α^{vis} is the cross-section (after cuts)

MadAnalysis 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).

Introduction
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My first analysis
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Advanced functionalities
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Developer-friendly mode
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Summary
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Step 5 : diplaying results

Dataset	# events	Mean	RMS	% 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