

Photon interactions in MadGraph/MadEvent v4

Michel Herquet (UCLouvain - CP3)
& the MG/ME development team

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GENESIS 1:3-4

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- * MadGraph/MadEvent v4
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Why tree-level?

- * Most of the current collider pheno is done at tree-level both at the theoretical and (even more) at experimental level.
- * Experiments may need fully exclusive descriptions.
- * MC at NLO are very recent (and impressive) achievements, but currently limited to a small set of key SM processes.

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sometimes the **only way** to bring ideas to life and test them in the experiments!

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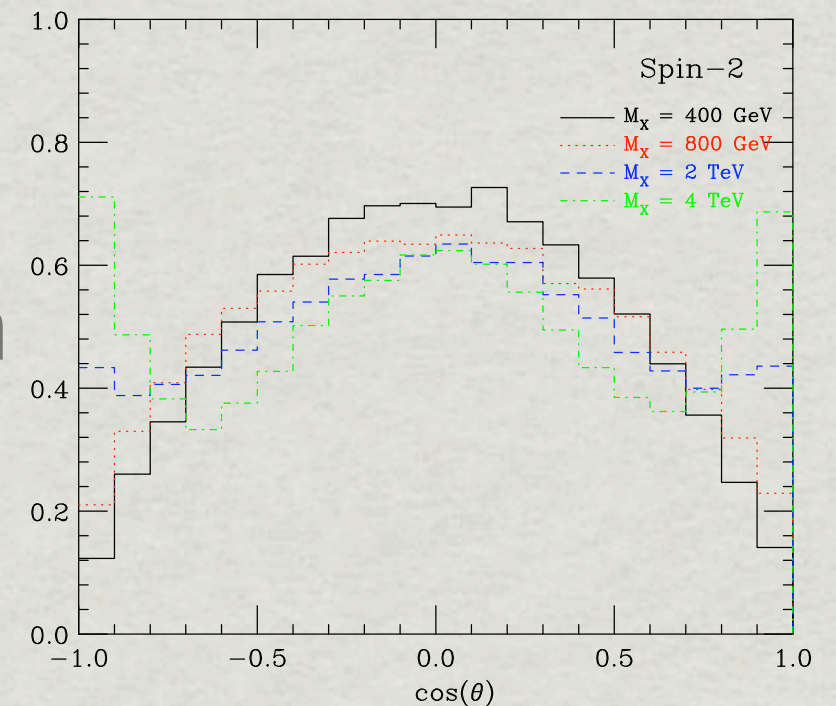
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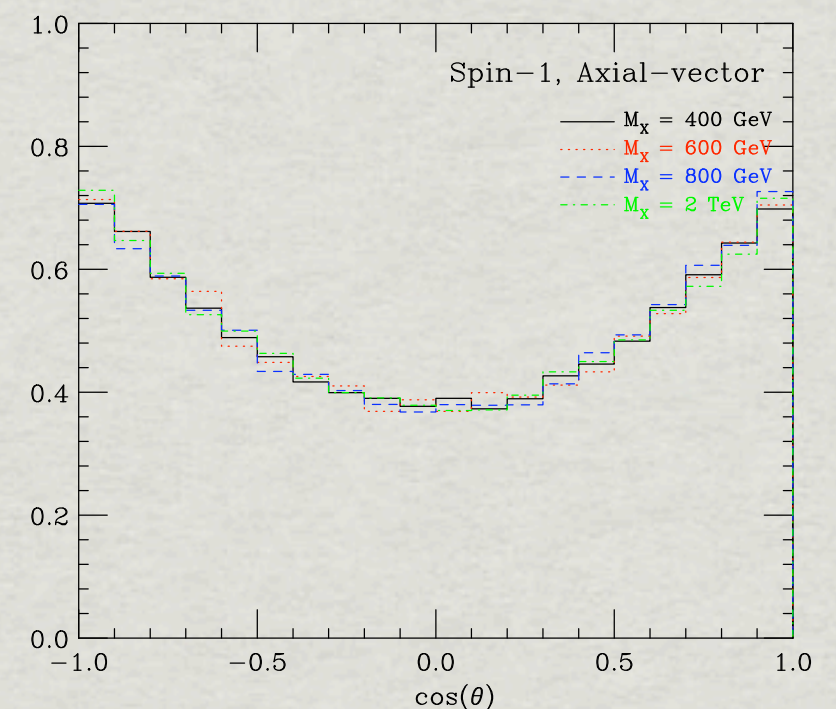
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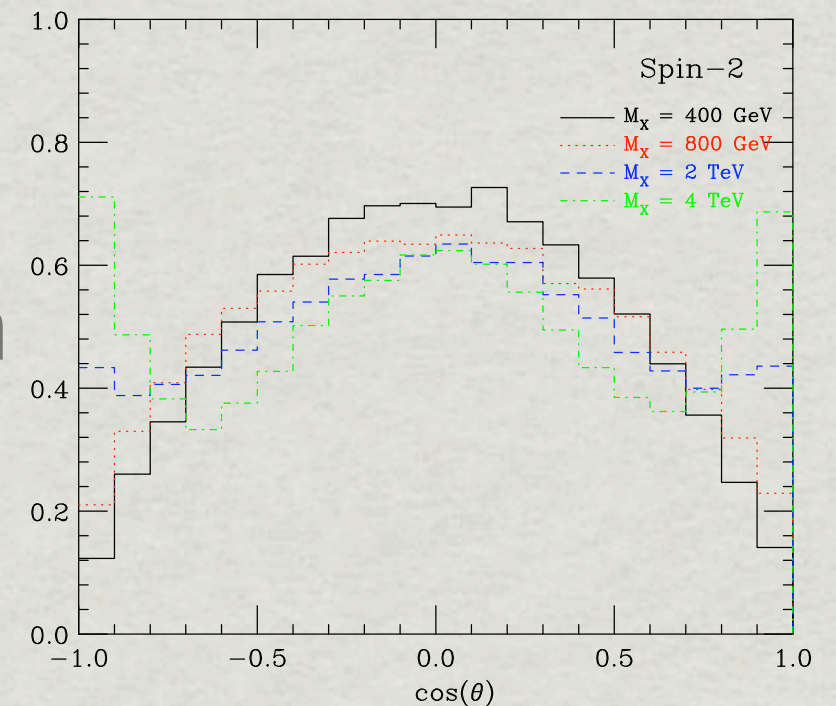


(b)

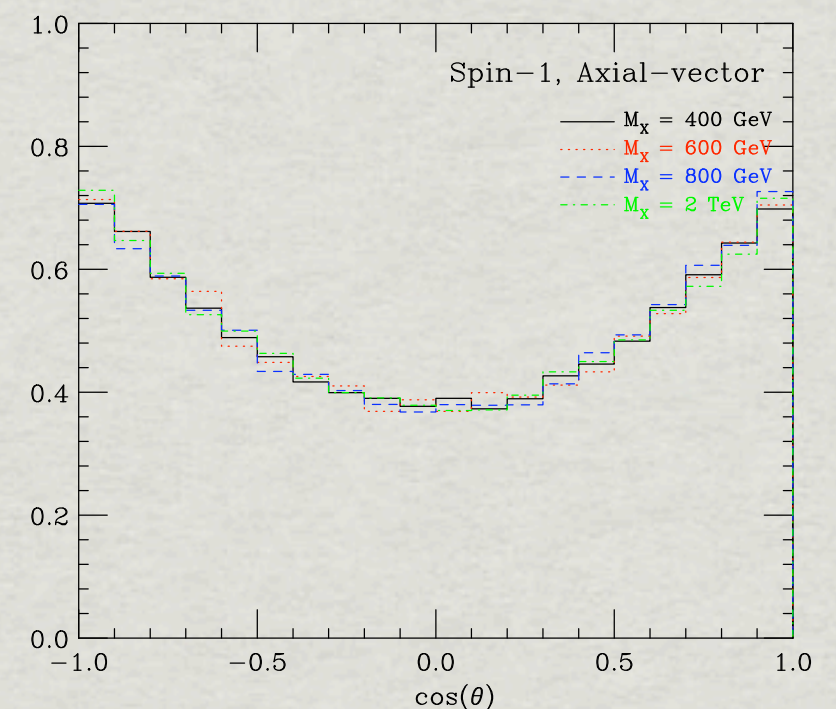


Why Matrix Elements ?

- * “Natural” approach for phase space regions where perturbative expansion is effective (hard, high angle, ...)
- * Take into account all possible interferences
- * Simulate correctly spin correlations
- * Can be used for new analysis techniques

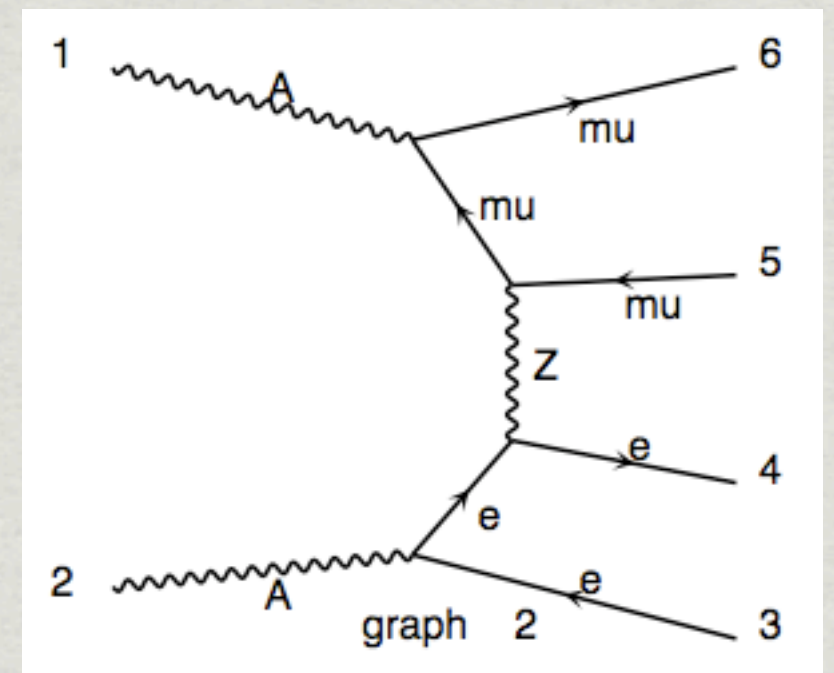


(b)



MadGraph

- * Basic building blocks : **Feynman diagrams**
- * Generates “empty” topologies for $m > n$ diagrams and “fill” them using valid interaction vertices
- * Knowing particles properties, produces Feynman diagrams and **suitable calls to the HELAS library**



MadEvent

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- * **But** : time expensive, peaks must lie on integration variables

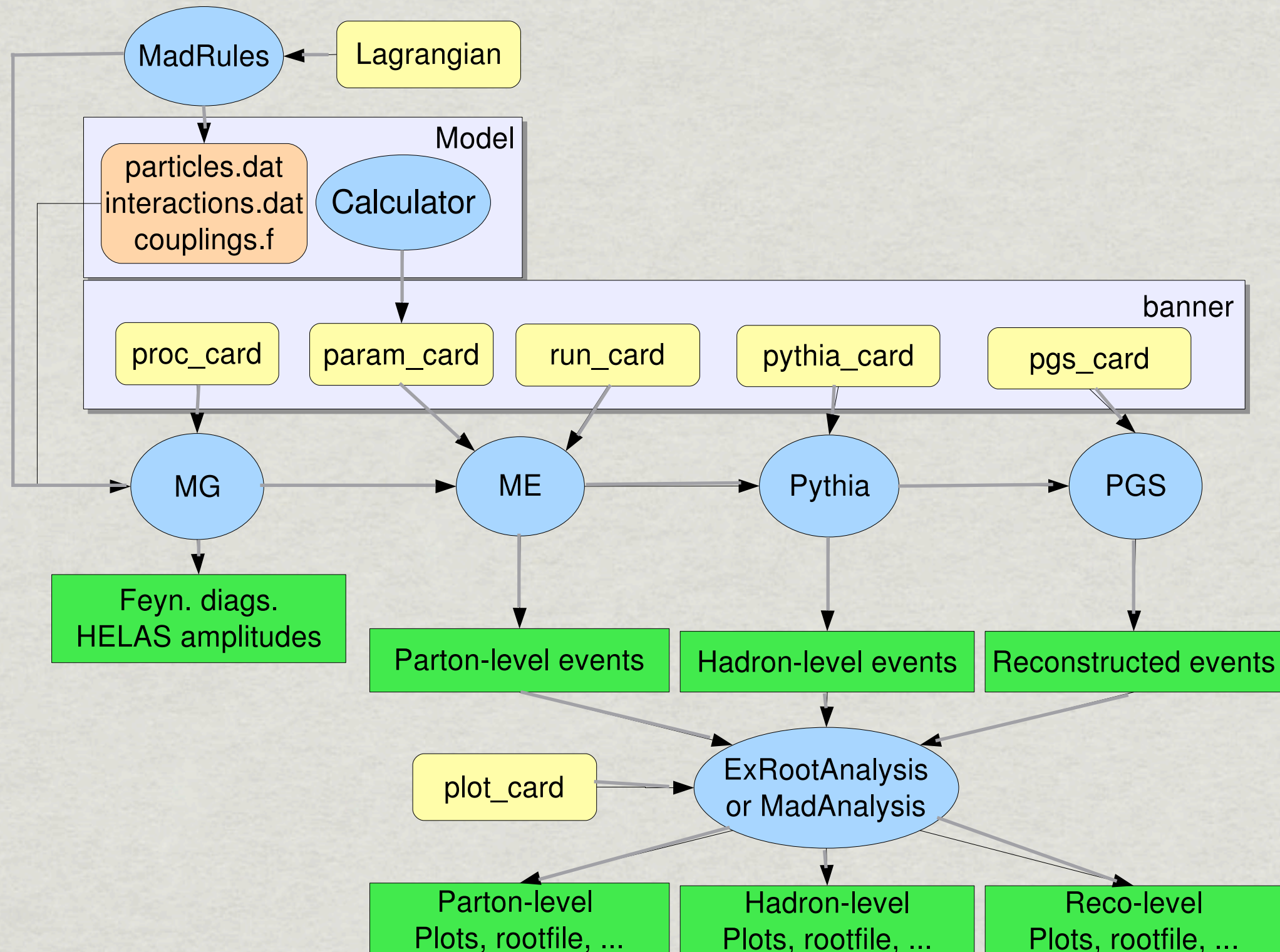
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- * **But** : time expensive, peaks must lie on integration variables
- * **Solutions exist** : Multi-Channel Integration (Amegic, Nextcalibur, Whizard), **Single Diagram Enhanced MCI** (MadEvent) :

$$\left| \sum_i A_i \right|^2 = \sum_i \left(\frac{|A_i|^2}{\sum_j |A_j|^2} \left| \sum_k A_k \right|^2 \right)$$

- * One peaked function per diagram
- * Parallel in nature

MadGraph/MadEvent Flow



New web generation

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- * The new **web generation**:
 - * User **inputs model/parameters/cuts**.
 - * Code runs in **parallel** on one of **our farms** (UCL, UIUC, Roma)
 - * Returns **cross section, plots, parton-level events**.
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- * **Advantages**:
 - * **Reduces overhead** to getting results
 - * Events can easily be shared/temporarily stored

MG/ME v4 features

- * **Helicity amplitudes**, based on HELAS
- * **Parallel** phase space integration (up to 10 external particles)
- * **Les Houches Accord standards** for model parameters (LHA) and for the parton-level event files (LHEF)
- * CKKW and kt-MLM **matching methods**
- * **Interfaces** for Pythia, Sherpa (and Herwig)
- * **Analysis platforms**: ExRootAnalysis and MadAnalysis
- * **“Decay chains” syntax** for diagram generation

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Basic principle...

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... it can do it as well for collisions
involving photon(s)

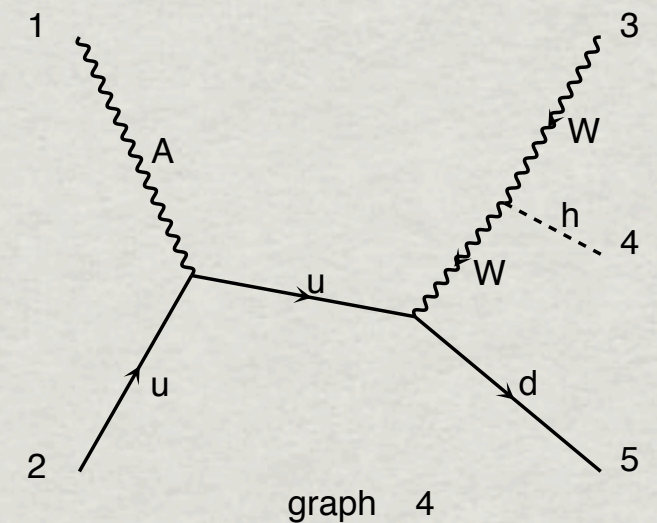
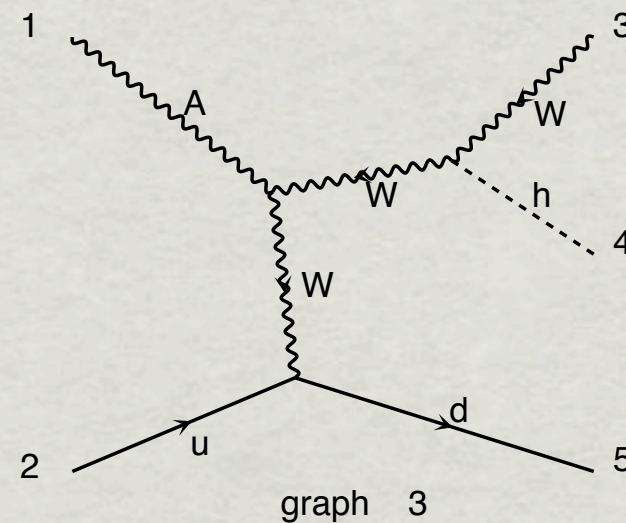
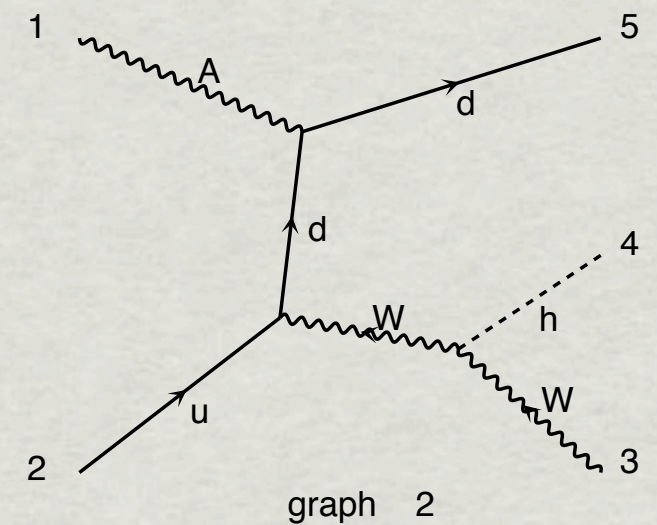
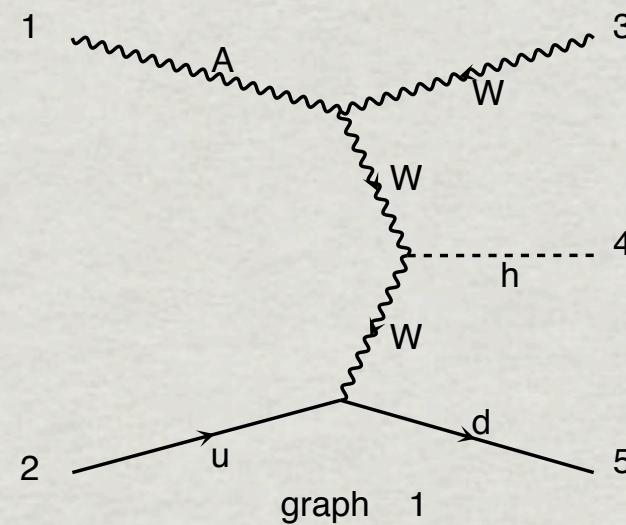
Matrix elements for photon physics

- MadGraph can generate diagrams for any hard scattering process with $\gamma\gamma$, γe and γp as initial states

- At this stage, no assumption is made on photon exact origin

- E.g. Associated WH production at the LHC

Diagrams by MadGraph a u -> w+ h d



Events production for photon physics

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- * Both **electron** and **proton** (no breaking) beams have been **implemented as photon sources in MadEvent** (status 2 and 3 for the photon beam) by members of the UCL-CP3 photon group (Thanks!).

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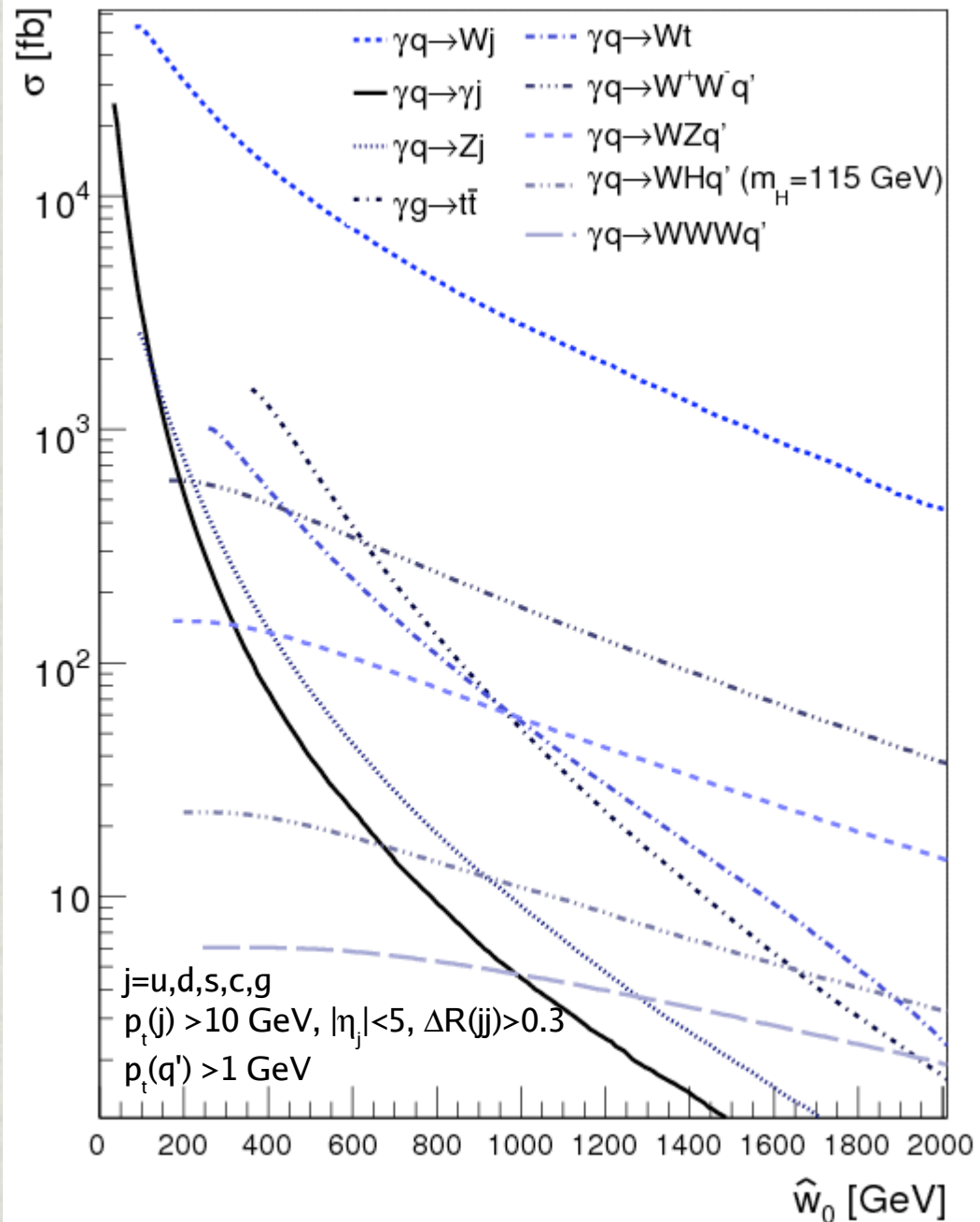
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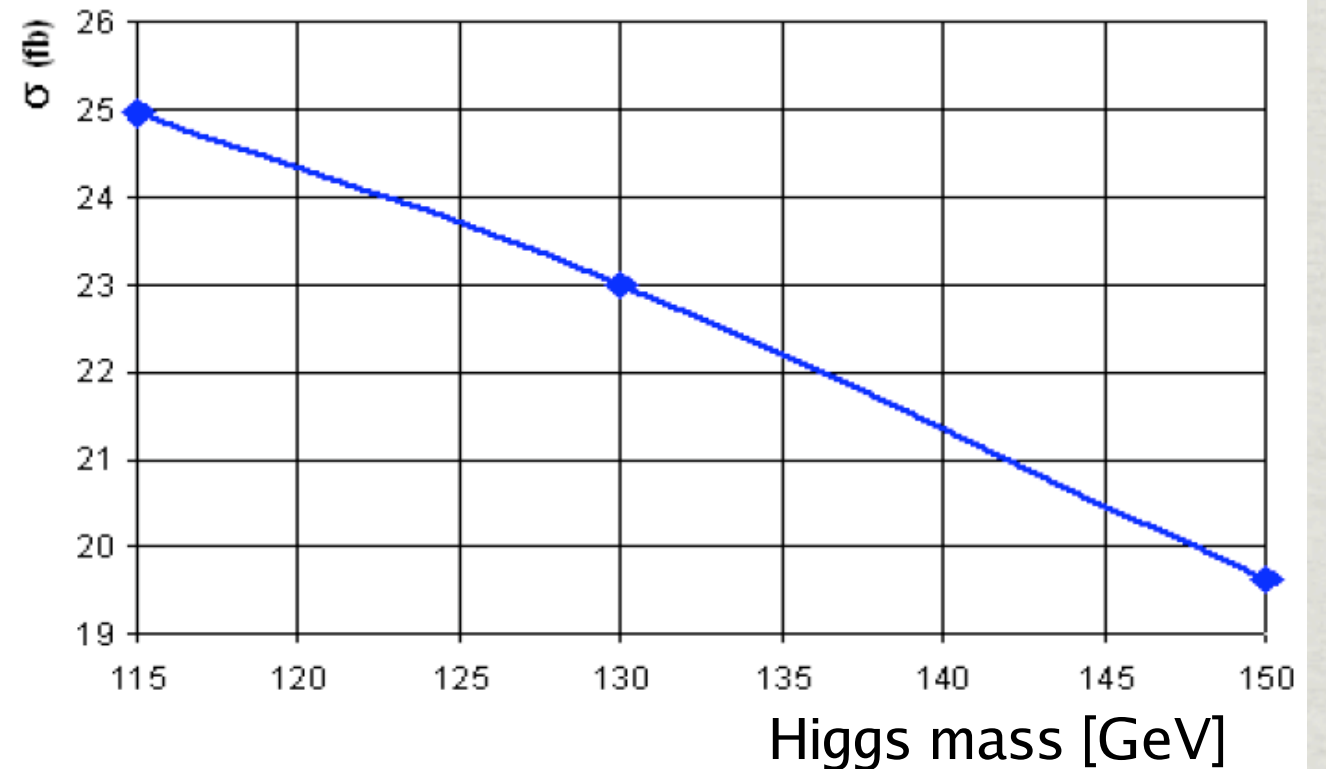
- * **Proton**: more model dependent since the proton is not an elementary particle (V.M.Budnev et al., Phys.Rep. 15C (1975) 181)
- * No polarized γ beams yet, but trivial to implement (already there for electrons)

Real-life applications

Obtained using MadGraph/MadEvent



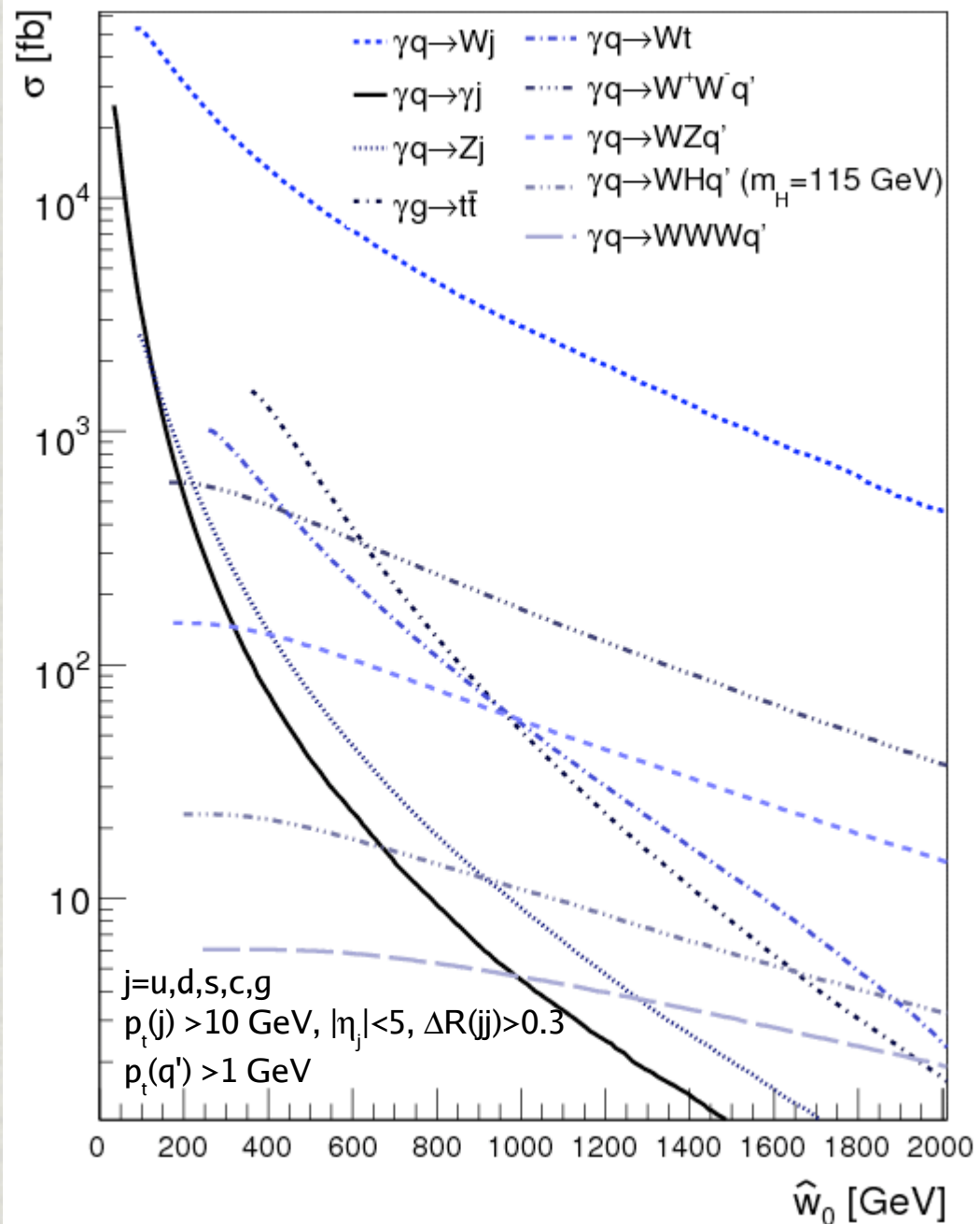
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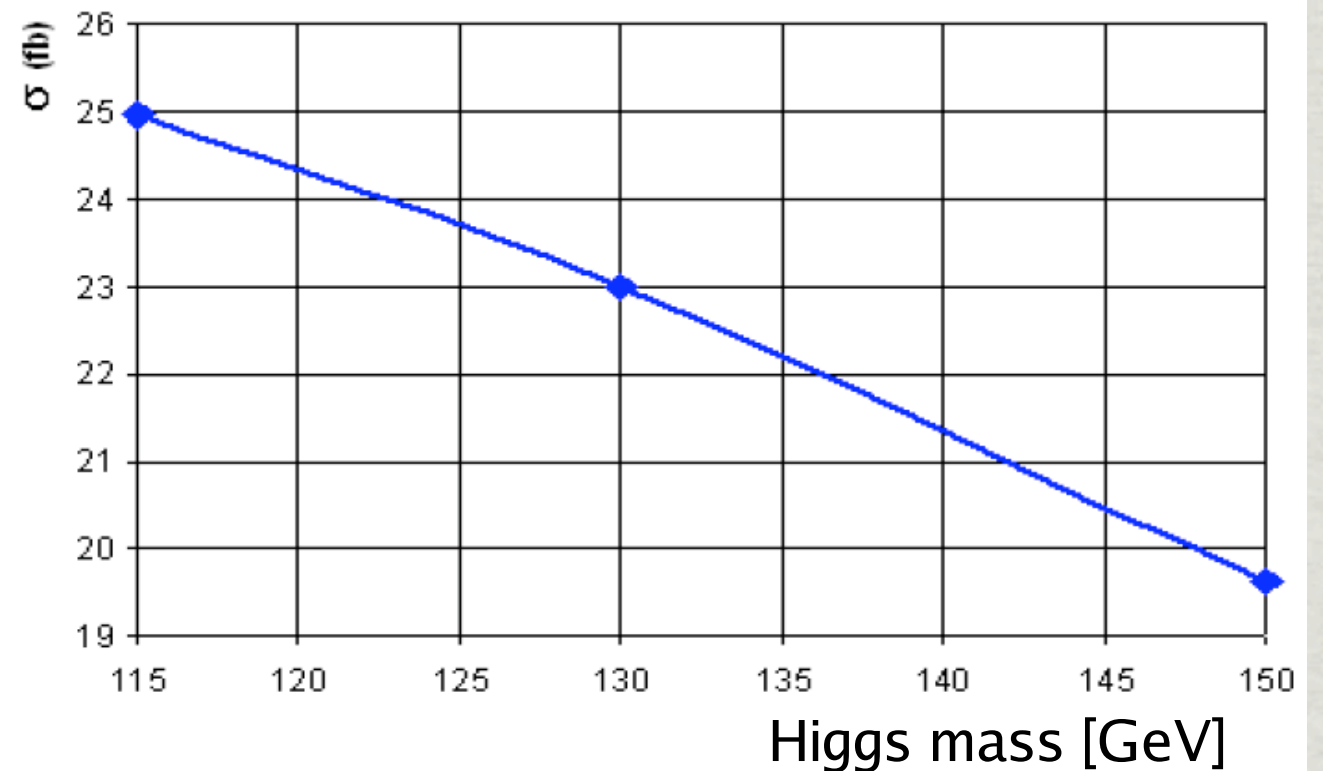
S. OVYN, SEE SEVERINE'S PRESENTATION

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- * MG/ME deals with different physical models as directories containing:
 - * **particles.dat** : particle list with name, PDG codes, properties, ...
 - * **interactions.dat** : list of all possible 3- and 4-vertices
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 - * **couplings.f** : analytic expressions for Feynman rule couplings
- * MG/ME comes with several **predefined models**: **MSSM, 2HDM, HEFT, BSM top, ...**

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- * **USRMOD**: script allowing users to implement their own models by modifying the SM default
- * **Limitation**: computing Feynman rules by hand is a hard task...

FeynRules

- * New package to **compute Feynman rules from Lagrangian**
- * **Theorist friendly** Mathematica package
- * Completely **generic**, zeroth level output is TeX!
- * Interfaces for **MG/ME**, but also for **FeynArts**, **Sherpa** and **CalcHEP**
- * Standard Model and simple models implemented and tested, MSSM on its way

FeynRules (example)

SM SCALAR AND EXTRA SINGLET(S)

J. J. VAN DER BIJ

*Institut für Physik, Albert-Ludwigs Universität Freiburg, H. Herderstr. 3,
79104 Freiburg i.B., Deutschland*

[arXiv:0707.0359]

$$L = -\frac{1}{2}(D_\mu\Phi)^\dagger(D_\mu\Phi) - \frac{\lambda_0}{8}(\Phi^\dagger\Phi - f_0^2)^2$$
$$- \frac{1}{2}(\partial_\mu H)^2 - \frac{\lambda_1}{8}(2f_1 H - \Phi^\dagger\Phi)^2$$

FROM CLAUDE DUHR'S PRESENTATION AT MC4BSM08

FeynRules (example)

$$\Phi = \{0, h + f0\}$$

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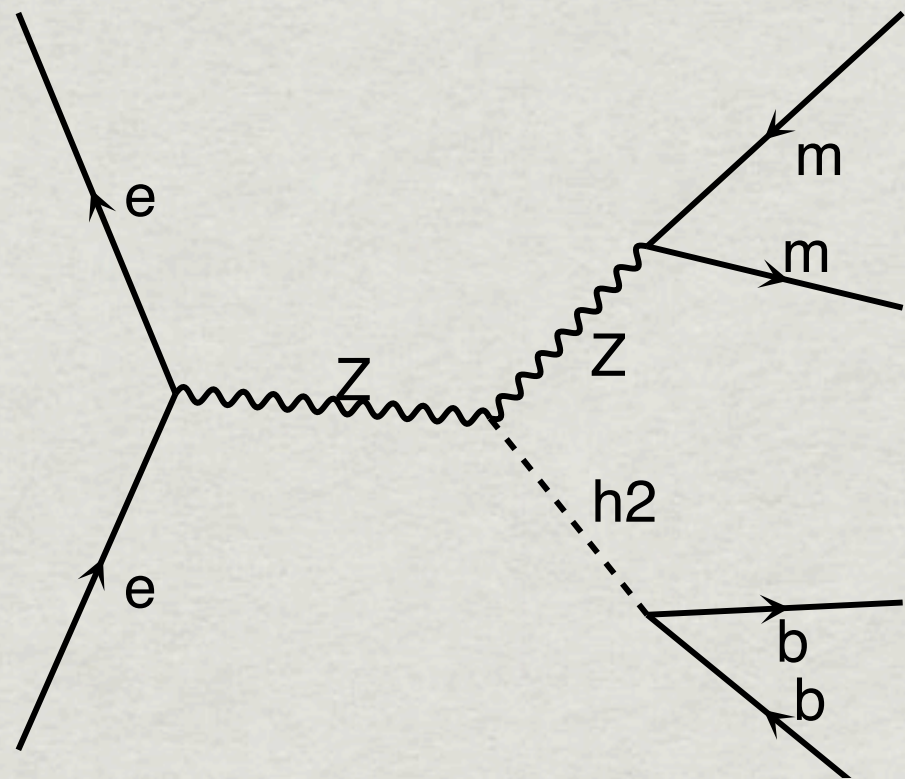
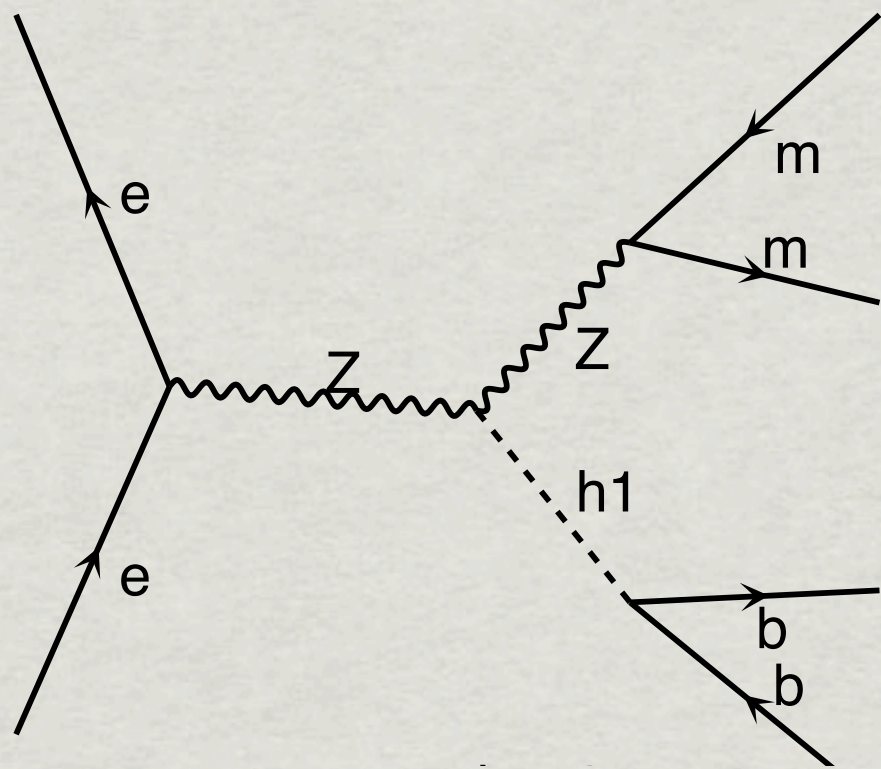
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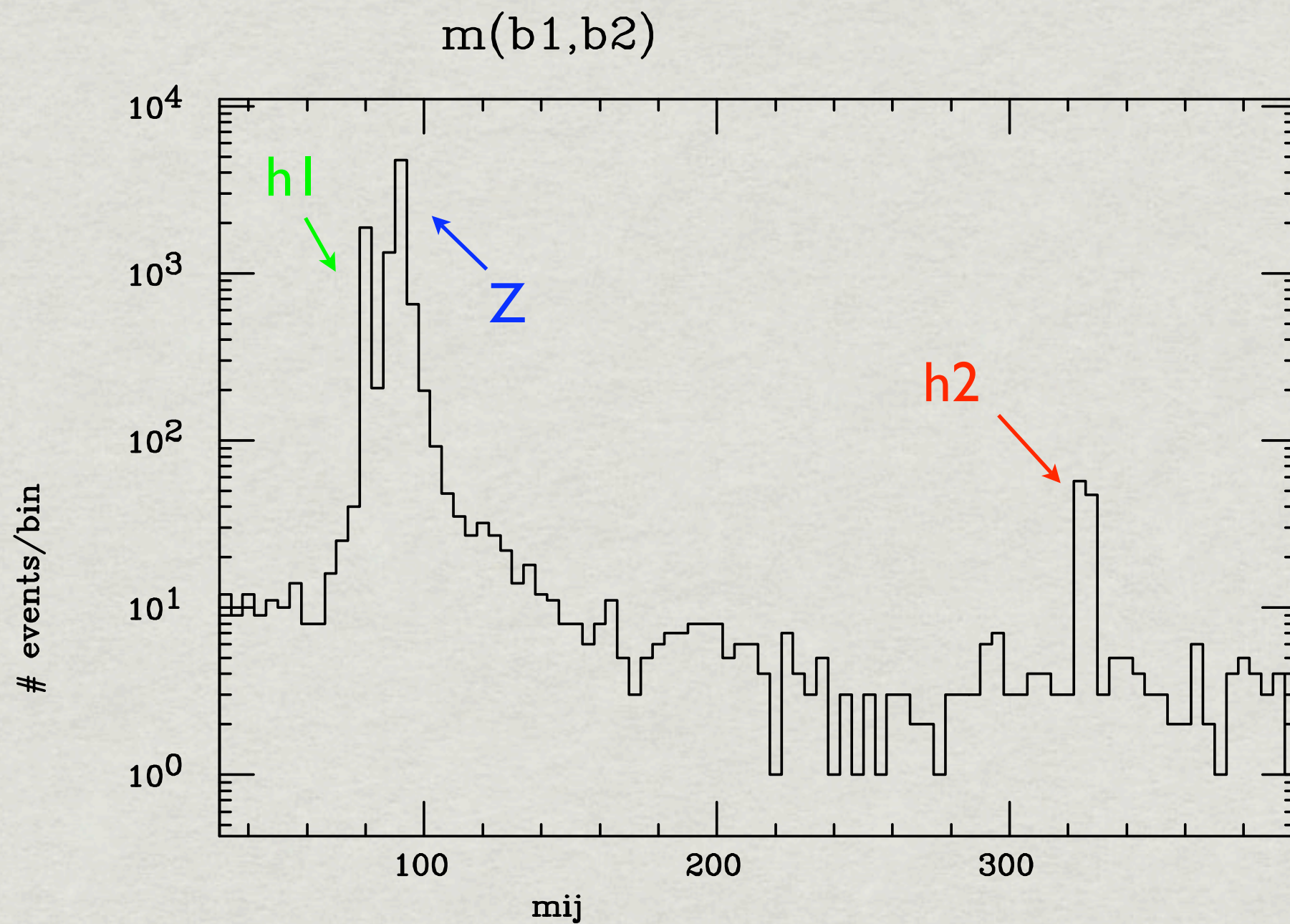
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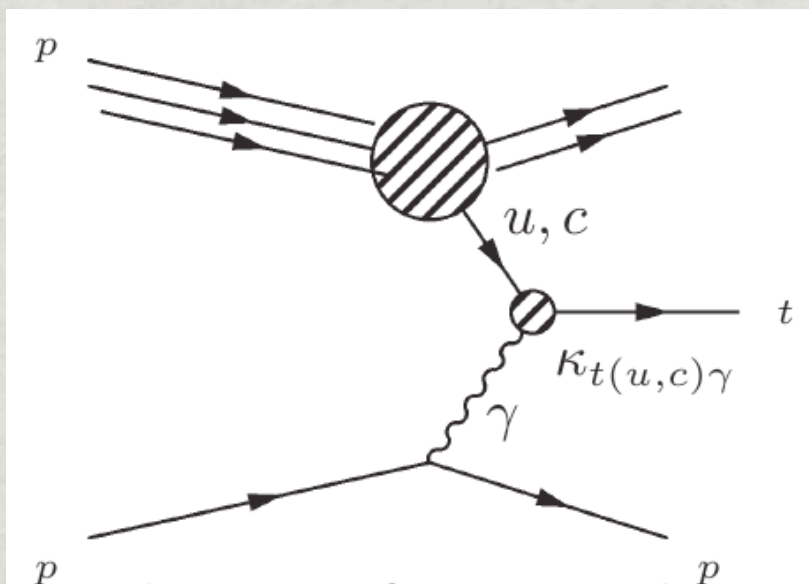


FeynRules (example)



BSM with photons

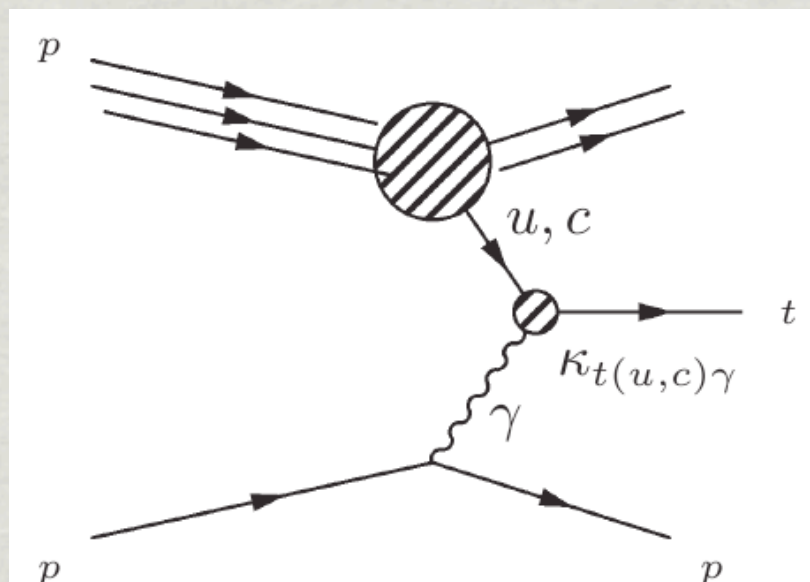
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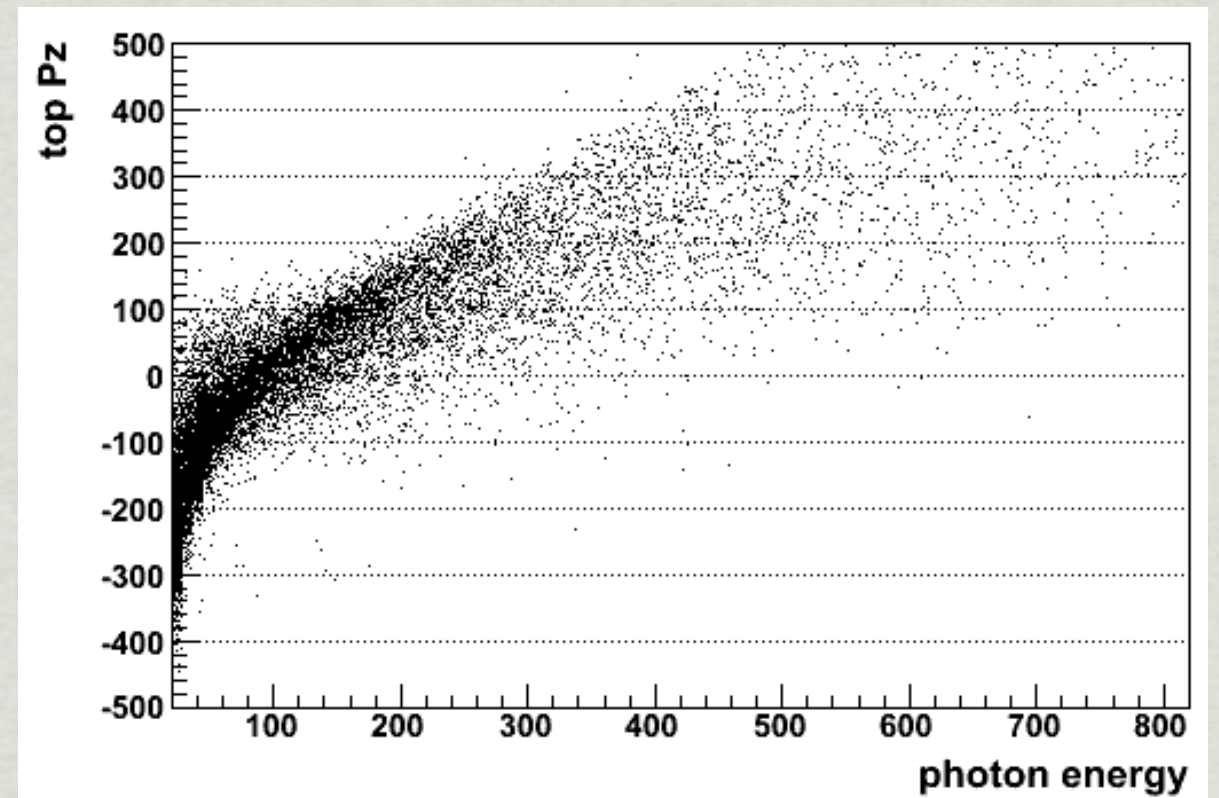
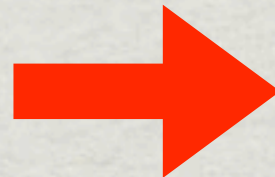
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**MG/ME
USRMOD**



J. DE FAVEREAU, SEE JEROME'S TALK

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- * It can deal with initial state photons, either as real beams or coming from e and p, using EPA
- * Various BSM models are now available, and new ones have never been so easy to implement

Thanks for your attention!