

Off-Shell/Interference effects Status and prospects in MadGraph5_aMC@NLO

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LHC HXSWG - Off-shell-Interference group

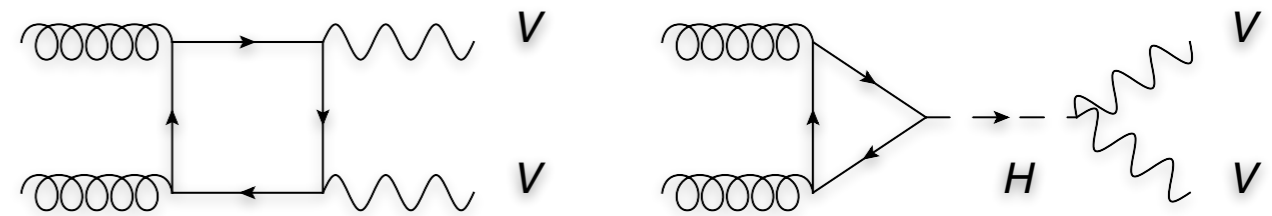
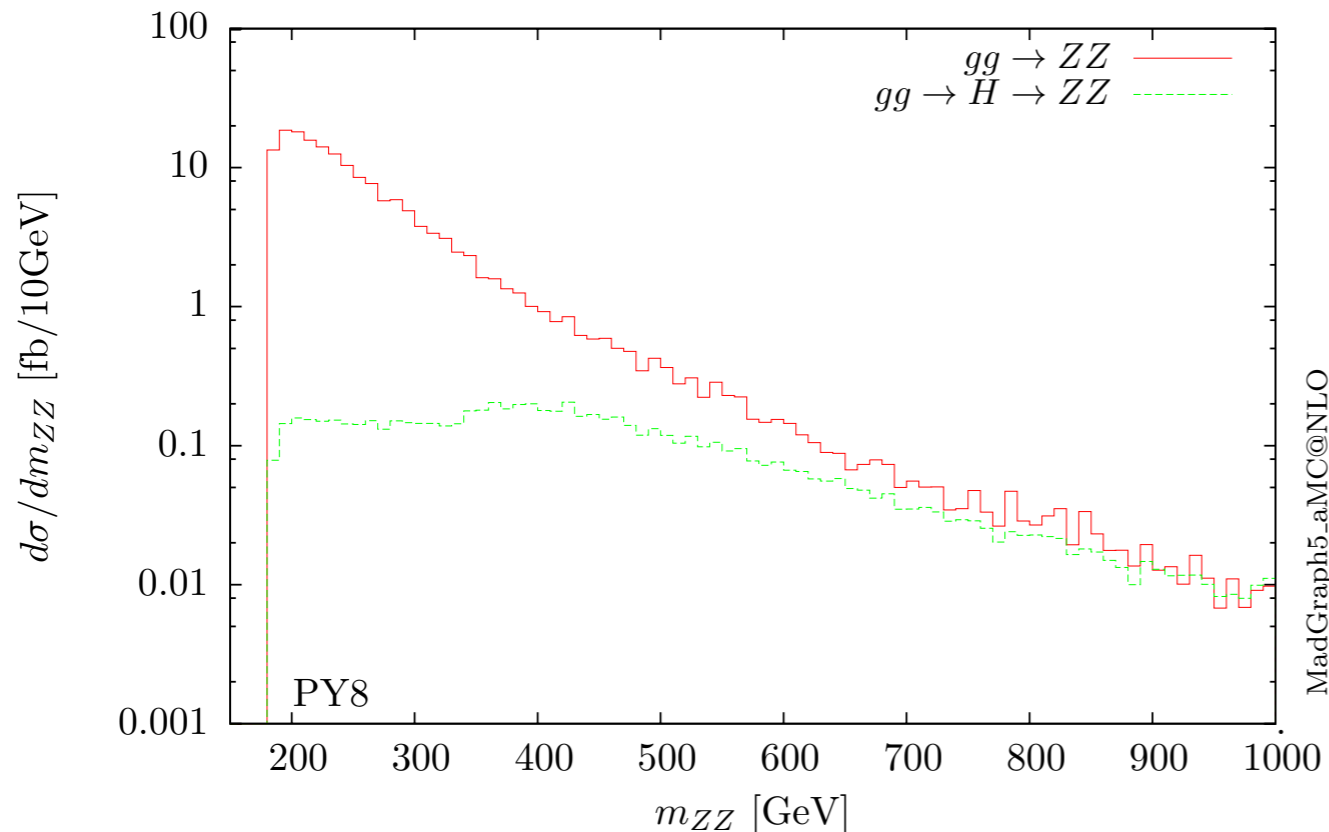
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Status of MG5_aMC

- In general any SM process (up to $2 \rightarrow 4$, tree-level born) possible in the MG5_aMC framework at NLO+PS or FxFx (merging at NLO) fully automatically (no external dependences) with Pythia8 or HW++.
- Extension to HEFT available too (but not complete yet) usable for a rather large class of processes involving the Higgs. 2HDM available.
- Matrix elements for loop-induced processes available (through MadLoop), yet the automation of the event generation still in beta.
- NLO+PS or Merged samples for loop induced processes: easy to obtain, are available on a process-by-process basis:
 - H+Jets with KT-MLM with loop corrections [[Alwall, arXiv:1110.1728](#)]
 - ggF at NLO+PS [[Frixione and Wieseemann, https://cp3.irmp.ucl.ac.be/projects/madgraph/wiki/HSushi](#)]
 - HH at NLO+PS (two-loop approx) [[Frederix et al. arxiv:1401.7340](#), [Hespel, Lopez-Val, Vryonidou arxiv:1407.0281](#), [FM, Vryonidou, Zaro, arXiv:1408.6542](#)]

Interference effects in $g g \rightarrow V V$

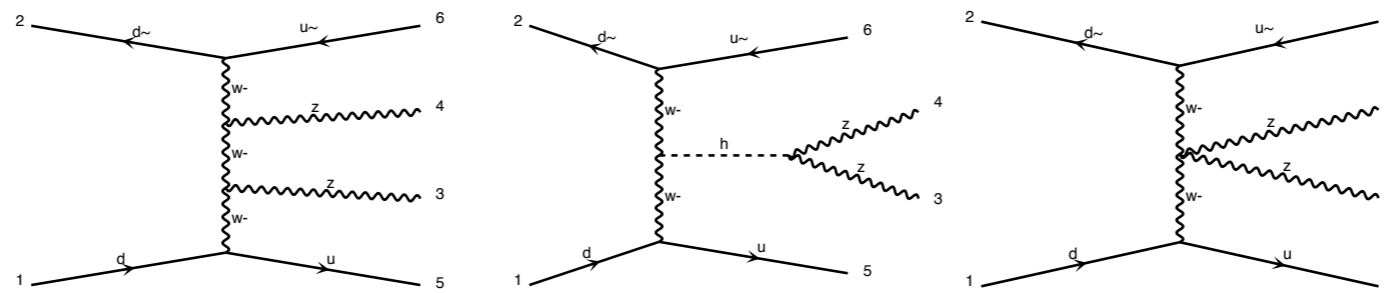
- Automation of event generation for loop-induced processes at LO :
In progress, alpha version released, internal validation on going.
- Plan:** Codes for $VV + \text{jets}$ KT-MLM merged samples are in preparation.



Example: running just on-shell Zs

- 1) Signal+Background
- 2) Signal

Interference effects in VBF



- LO computations are automatized (including decays):

`MG5_aMC>generate p p > e- e+ mu- mu+ j j QCD=0`

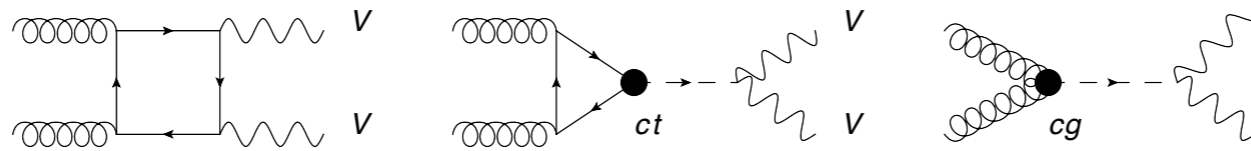
60 processes with 40524 diagrams generated in 53.550 s

Total: 60 processes with 40524 diagrams

leads to ~500 processes: fine on a cluster

- NLO computation of purely LO EW processes seems challenging at present.

EFT operators



- EFT operators:

The Higgs Characterisation model available at NLO+PS

[Artoisenet et al., arxiv:1306.6464]

$$\mathcal{L}_0^V = \left\{ c_\alpha \kappa_{\text{SM}} \left[\frac{1}{2} g_{HZZ} Z_\mu Z^\mu + g_{HWW} W_\mu^+ W^{-\mu} \right] \right. \\
- \frac{1}{4} [c_\alpha \kappa_{H\gamma\gamma} g_{H\gamma\gamma} A_{\mu\nu} A^{\mu\nu} + s_\alpha \kappa_{A\gamma\gamma} g_{A\gamma\gamma} A_{\mu\nu} \tilde{A}^{\mu\nu}] \\
- \frac{1}{2} [c_\alpha \kappa_{HZ\gamma} g_{HZ\gamma} Z_{\mu\nu} A^{\mu\nu} + s_\alpha \kappa_{AZ\gamma} g_{AZ\gamma} Z_{\mu\nu} \tilde{A}^{\mu\nu}] \\
- \frac{1}{4} [c_\alpha \kappa_{Hgg} g_{Hgg} G_{\mu\nu}^a G^{a,\mu\nu} + s_\alpha \kappa_{Agg} g_{Agg} G_{\mu\nu}^a \tilde{G}^{a,\mu\nu}] \\
- \frac{1}{4} \frac{1}{\Lambda} [c_\alpha \kappa_{HZZ} Z_{\mu\nu} Z^{\mu\nu} + s_\alpha \kappa_{AZZ} Z_{\mu\nu} \tilde{Z}^{\mu\nu}] \\
- \frac{1}{2} \frac{1}{\Lambda} [c_\alpha \kappa_{HWW} W_{\mu\nu}^+ W^{-\mu\nu} + s_\alpha \kappa_{AWW} W_{\mu\nu}^+ \tilde{W}^{-\mu\nu}] \\
\left. - \frac{1}{\Lambda} c_\alpha [\kappa_{H\partial\gamma} Z_\nu \partial_\mu A^{\mu\nu} + \kappa_{H\partial Z} Z_\nu \partial_\mu Z^{\mu\nu} + (\kappa_{H\partial W} W_\nu^+ \partial_\mu W^{-\mu\nu} + h.c.)] \right\} X_0$$

$$\mathcal{L}_0^f = - \sum_{f=t,b,\tau} \bar{\psi}_f (c_\alpha \kappa_{Hff} g_{Hff} + i s_\alpha \kappa_{Aff} g_{Aff} \gamma_5) \psi_f X_0$$

Other operators can be easily implemented at the tree level. Operators in the loops need UV and R2 counter terms: need care and validation. This is on-going for several classes of operators in particular those involving the top quark.

Summary

- MG5_aMC framework public since 16th Dec 2013. Fully contained short-distance event generator at NLO+PS or FxFx (merging at NLO), fully automatic (no external dependences) with Pythia8 or HW++.
- NLO+PS or Merged samples for loop induced processes: easy to obtain, are currently available on a process-by-process basis on request. Automation in progress.
- In case of need and upon requests/ideas, support can be provided for dedicated implementations (as always).