Off-shell simulation tools

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for the off-shell subgroup conveners
Introduction

Following discussions in the EFT interpretations and theory uncertainties subgroups, we would like to list a set of simulation tools available for use.

Issues summarized in the second joint meeting

A key question is to assign reliable systematics on the unknowns just as much as being able to simulate the processes

- What do experimentalists use?
  - Current state-of-art corrections/tools and how they are applied (including those on the signal)
  - Do theorists have suggestions to improve these existing ingredients?

- SMEFT tools at tree and loop level for off-shell signal and background:
  - What is available now? What is needed for future studies?

- EFT fits compatibility between ATLAS and CMS:
  - Do we have tools to convert results and to validate different generators/parameterization techniques?
  - What do we need for future studies?

- Are tools for specific BSM extended with higher-dimensional operators needed?

- Can start listing them under the dedicated twiki
  - Also encourage active discussion on the e-group 😊
Modeling of the non-interfering backgrounds

→ One of the main sources of uncertainty in the determination of off-shell signal strength is the uncertainty on the NLO EW correction on the VV backgrounds as presented in the first theory uncertainties meeting.
→ It seems that the tool to use is MATRIX in this case.
→ Since the experiments target $4\ell$ and $2\ell2\nu$ final states, $WZ$ (or $WW$) are both as relevant as $ZZ$.
→ Can the experiments / theorists share calculations if they already exist?

→ Another aspect is QCD corrections on VV:
→ $\sim10\%$ effects on $N_{jets} = 1$ at NNLO.
→ A first comparison was shown in the theory uncertainties meeting.
→ Volunteers for more studies are needed to assess systematics and corrections differentially.
Modeling of the signals

→ In gluon fusion, we have the usage of SHERPA+OpenLoops and MCFM+JHUGen dedicated simulations, or POWHEG simulation+reweighting procedures
→ A comparison of differential $p_T^H, N_{jets}$ distributions would be useful to compare since gluon fusion is one of the key backgrounds to rarer processes like VBF
→ Need to understand differences in how K factors are applied and develop a common approach
→ How to integrate the EFT models?

→ Similarly for VBF, we have the usage of aMC@NLO, Phantom and MCFM+JHUGen dedicated simulations, or POWHEG simulation+reweighting procedures
→ Need a comparison of the used techniques to understand the level of agreement between each other – and where they disagree to determine the level of systematics
→ The additional complexity in EFT models is to be able to simulate BSM couplings in two vertices vs one.
  → Comparisons between different approaches again important to understand BSM-specific systematics

→ In SM, VH contribution is negligible, but in BSM, off-shell VH is enhanced to the same level as VBF [1, 2]
→ Note that from an experimental point of view, a categorization for VBF vs gluon fusion puts VH events most likely in a gluon fusion/untagged category. Therefore, this contribution would show up as enhancement in these categories, correlated with enhancements in the VBF category.
→ How can we include this effect reliably?
Last but not least: Reweighting tools for EFT

→ The availability of reweighting tools is necessary to reinterpret existing simulation in the experiments

→ These simulations are generated with a certain set of couplings in mind, but if theorists express interest for specific couplings, we might want to apply reweighting on them.
   → Simulation usually take a lot of time to generate centrally within the experiments, so it is much easier to reweight existing ones if we know their input parameters.

→ How readily available are these tools? Can we document a set of recipes to use easily?
Thank you!