EFT in SHERPA

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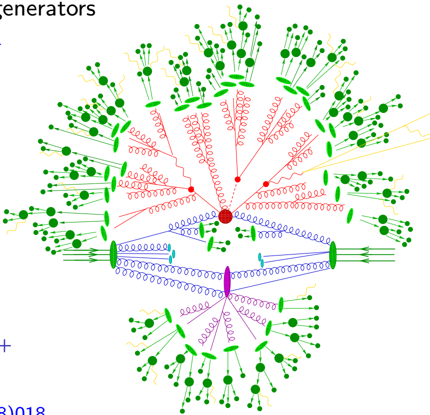
THE ROYAL SOCIETY

The SHERPA event generator framework

JHEP02(2009)007

- Two multi-purpose Matrix Element (ME) generators
  AMEGIC++ JHEP02(2002)044, EPJC53(2008)501
  COMIX JHEP12(2008)039, PRL109(2012)042001
- Two Parton Shower (PS) generators
  CSSHOWER++ JHEP03(2008)038
  DIRE EPJC75(2015)461
- A multiple interaction simulation
  à la PYTHIA AMISIC++ hep-ph/0601012
- A cluster fragmentation module
  AHADIC++ EPJC36(2004)381
- A hadron and τ decay package HADRONS++
- A higher order QED generator using
  YFS-resummation PHOTONS++ JHEP12(2008)018



Sherpa's traditional strength is the perturbative part of the event

LO, NLO, NNLO, LOPS, NLOPS, NNLOPS, MEPS, MENLOPS, MEPS@NLO

SHERPA-2.2.10

- SHERPA-2.2.10 released May '20
- contains bugfixes for all known bugs of SHERPA-2.2.9
- on-the-fly variations for
  - μ_R, μ_F and PDF in ME and PS
  - approx. NLO EW and subleading LO corrections
- default PDF: `NNPDF30_nnlo_as_0118`
- `UFO` support for BSM physics extended to be suitable also for `SMEFTsim`

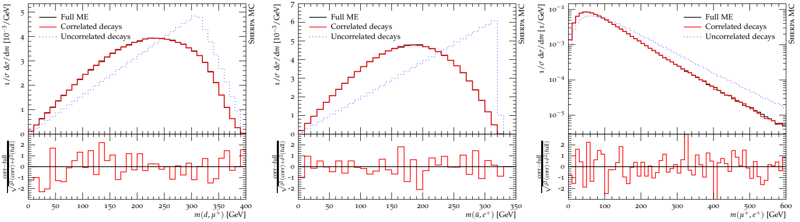
BSM in SHERPA

Höche, Kuttimalai, Schumann, Siegert EPJC75(2015)3,135

- full support for UFO model Degrande et.al. CPC183(2012)1201
- Lorentz structures automatically built, colour structures mapped on SM/MSSM-like (automatically built in SHERPA-3.0)
- automatic identification of all $1 \to 2$ and $1 \to 3$ decay channels of every unstable particle in the model
  $\to$ calculation of all decay widths (LO)
- per default all decay channel used
  $\to$ inclusive production
  $\to$ simple-to-use mechanism to select individual channels, cross section optionally adjusted accordingly
- spin-correlated decay chains of arbitrary length using spin density matrices Richardson JHEP11(2001)029, Knowles CPC58(1990)271

BSM in SHERPA

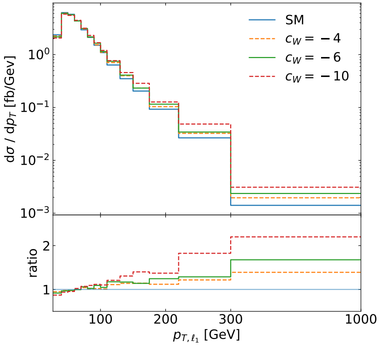
Höche,Kuttimalai,Schumann,Siegert EPJC75(2015)3,135



- simple three-step example:
  $pp \to \tilde{u}[\to d\chi_1^+[\to \chi_1^0 W^+[\to \mu^+\nu_\mu]]]\ \tilde{u}^*[\to \bar{u}\chi_2^0[\to e^+\tilde{e}^-[\to e^-\chi_1^0]]]$
- use truncated showers for QCD radiation off intermediate particles
- QED correction for each decay in YFS soft-photon resummation

UFO/EFTs in SHERPA-2.2.10

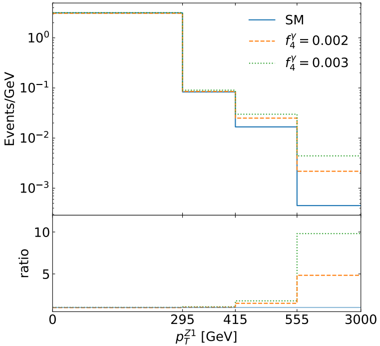
- updated for `Python3`
- full support for `SMEFTsim`
- adapted order counting to allow for neg. coupling orders
- possibility to specify coupling order on level of $|\mathcal{M}|^2$ or $\mathcal{M}$ to allow to calculate $|\text{EFT}_6|^2$
- added defaults for EW parameters ($\sin\theta_w$, v, ...)
  ⚠ $\rightarrow$ may not be consistent between ME, PS, decays
- allow for form factors in Lorentz stuctures



$pp \rightarrow \ell\ell\nu\nu$ in SM+EFT_6

AGCs in SHERPA

- implementation of Hagiwara et.al. Nucl.Phys.B282(1987)253 (aTGC), Gangemi et.al. hep-ph/0001065 (aQGC) only available in SHERPA-2.1
- discontinued in SHERPA-2.2 series as clashed with more generic UFO support
- continued demand for neutral aTGC, but only at dim-8 in SMEFT
- includes form factor unitarisation



$\mathrm{pp} \to ZZ$

Conclusions

- full support for UFO models (incl. SMEFTsim)
- UFO models can be used in multijet merged setups
- old AGC model discontinued in favour of UFO
  $\rightarrow$ possibility to resurrect old parametrisation for SHERPA-3.0
- fully spin-correlated decay chains of arbitrary lengths
- fully showered and hadronised predictions

https://sherpa-team.gitlab.io

Backup

Acronyms and nomenclature

Fixed order calculations

- matrix elements only, implies fixed multiplicities
- no parton shower, no non-perturbative physics, no particle level

⇒ LO, NLO, NNLO

Parton shower matched calculations

- combination of fixed order calculation and parton shower for one multiplicity
- particle level predictions, no multijet observables

⇒ LOPS, NLOPS, NNLOPS

Multijet merged calculations

- combination of parton shower matched calculations for increasing final state multiplicities (mostly jets)
- particle level predictions, multijet observables

⇒ MEPS(@LO), MEPS@NLO (special case MENLOPS)