Status of SHERPA

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ATLAS–CMS Monte Carlo Generators Workshop

SHERPA-2.2.0

- SHERPA-2.2.0 released Jul '15
- contains bugfixes for all known bugs in 2.1.1
- `UFO` support for BSM physics
- new parton shower DIRE in addition to CSSHOWER
- on-the-flhy scale variations for ME part in LO, LOPS, MEPS, NLO, MC@NLO – MEPS@NLO coming in SHERPA-2.2.1
  $\rightarrow$ use named weights in HEPMC (av. since HEPMC-2.06)
- interface changes in hard decays allowing larger flexibility including/excluding individual decay channels and overriding computed widths and branching ratios
- allow to force HEPMC event record into pure tree structure, lost information available through disconnected vertices
- new default PDF: `NNPDF30_nnlo_as_0118`

$\Rightarrow$ new tune of non-perturbative models

forward jet excess

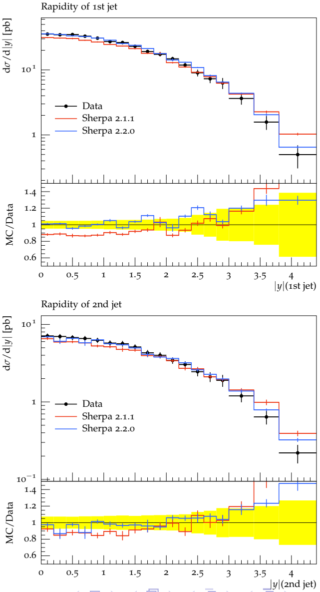
- forward jet excess in DY in SHERPA-2.1.1

→ linked to combination of parton shower recoil scheme, multiple interactions & beam remnants

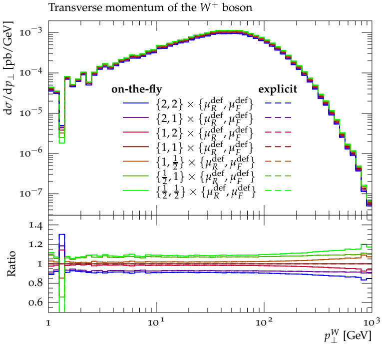
⇒ **fixed in SHERPA-2.2.0**

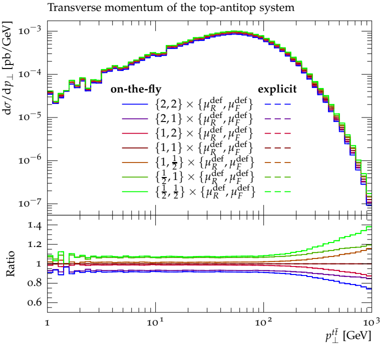
- parton shower changed, sizeable differences between 2.1.1 and 2.2.0 in parton shower sensitive regions expected

→ as seen in forward jets, this is not obvious in all cases



Scale variations in $pp \to t\bar{t}W^+$ (S-MC@NLO)

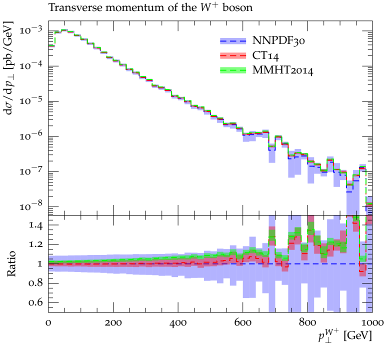


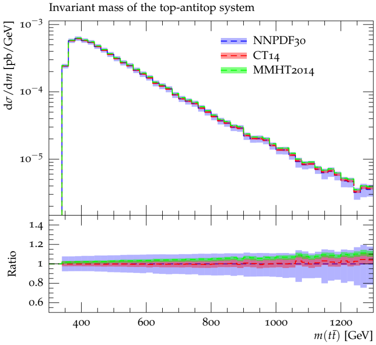



```
SCALE_VARIATIONS 0.25,0.25 0.25,1. 1.,0.25 1.,1. 1.,4. 4.,1. 4.,4.;
```

$\Rightarrow$ explicit $\mu_{R|F}$-variations exactly reproduced by on-the-fly variations ($\mu_{R|F}$ in parton shower not included, as usual)

PDF4LHC (old) variations in $pp \to t\bar{t}W^+$ (S-MC@NLO)






```
PDF_VARIATIONS NNPDF30_nlo_as_0118[all] CT14[all] MMHT2014nlo68cl[all];
```

$\Rightarrow$ combine with scale and α_s variation to arrive at full PDF4LHC unc.
central value + 217 variations (208 PDFs + 7 scales + 2 α_s)

Timings in $pp \to \ell^+\ell^- + \leq$ 4jets MEPS (LO)

weighted events

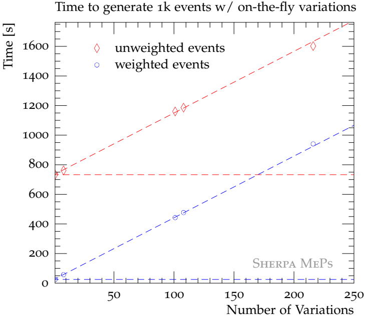
- low baseline per event timing (25s/1k)
- constant offset per computed variation

$\Rightarrow$ 217 vars. $\to$ factor 38

(partially) unweighted events

- high baseline per event timing (730s/1k)
- constant offset per computed variation

$\Rightarrow$ 217 vars. $\to$ factor 2.2



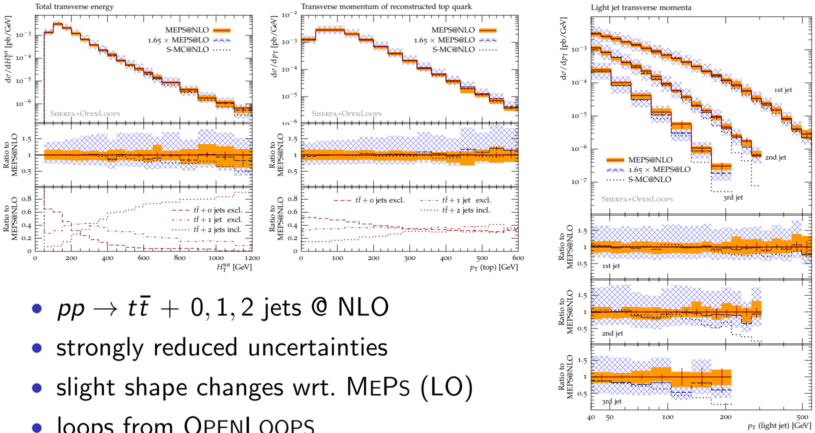
$\mu_{R\|F}$	$\to$	7
PDF (NNPDF30)	$\to$	100
$\mu_{R\|F}$+PDF	$\to$	107
PDF4LHC (old)	$\to$	217

$\to$ time to compute variations independent of event generation mode

$\Rightarrow$ **huge gain for standard (partially) unweighted events**

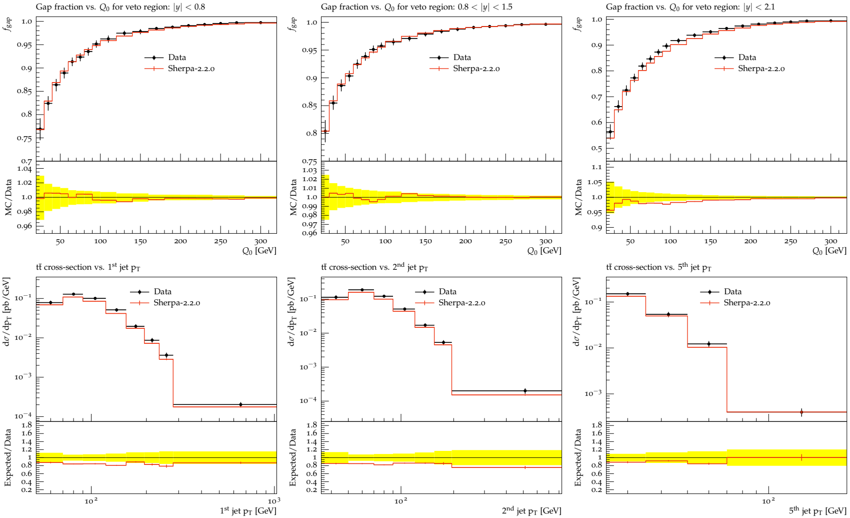
top physics

Höche, Krauss, Maierhöfer, Pozzorini, MS, Siegert in PLB748(2015)74-78



- $pp \to t\bar{t} + 0, 1, 2$ jets @ NLO
- strongly reduced uncertainties
- slight shape changes wrt. MEPS (LO)
- loops from OPENLOOPS

top physics


Gap fraction vs. Q_0 for veto region: $|y| < 0.8$
Gap fraction vs. Q_0 for veto region: $0.8 < |y| < 1.5$
Gap fraction vs. Q_0 for veto region: $|y| < 2.1$
f_{gap}
MC/Data
Q_0 [GeV]
Data
Sherpa-2.2.0
$t\bar{t}$ cross-section vs. 1st jet p_T
$t\bar{t}$ cross-section vs. 2nd jet p_T
$t\bar{t}$ cross-section vs. 5th jet p_T
$d\sigma/dp_T$ [pb/GeV]
Expected/Data
1st jet p_T [GeV]
2nd jet p_T [GeV]
5th jet p_T [GeV]

Higgs physics I

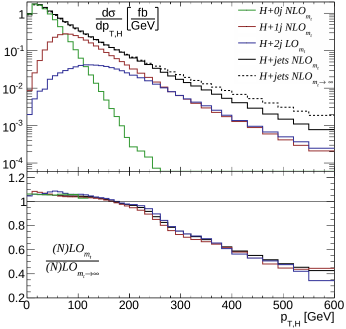
Buschmann, Goncalves, Kuttimalai, MS, Krauss, Plehn JHEP02(2015)038

$pp \to H$ + jets production (ggF)

- correction factor/weight

$$r_t^{(n)} = \frac{|\mathcal{M}^{(n)}(m_t)|^2}{|\mathcal{M}^{(n)}(m_t \to \infty)|^2}$$

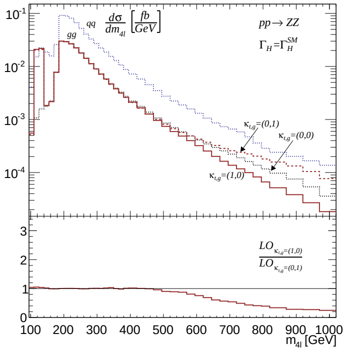
- loops from OpenLoops
- construct MePs@Nlo from reweighted S-Mc@Nlo
- factorised approach for unknown top mass dependence in V_n, otherwise exact NLO mass dependence

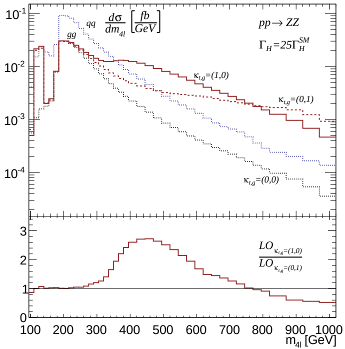


$$\mathrm{d}\sigma_n = \mathrm{d}\Phi_n\, r_t^{(n)} \left[\mathrm{B}_n + \mathrm{V}_n + \int \mathrm{d}\Phi_1\, \mathrm{D}_n\right] \widetilde{\mathrm{PS}}_n + \mathrm{d}\Phi_{n+1} \left[r_t^{(n+1)} \mathrm{R}_n - r_t^{(n)} \mathrm{D}_n\right]$$

Higgs physics II

Buschmann, Goncalves, Kuttimalai, MS, Kraus, Plehn JHEP02(2015)038





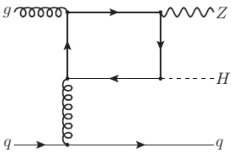
investigate new physics in $pp \to 4\ell$, $q\bar{q}$ @ NLO, gg @ LO
parametrised in κ framework, SM: $(\kappa_t, \kappa_g) = (1, 0)$

Higgs physics III

Goncalves, Krauss, Kuttimalai, Maierhöfer PRD92(2015)7,073006

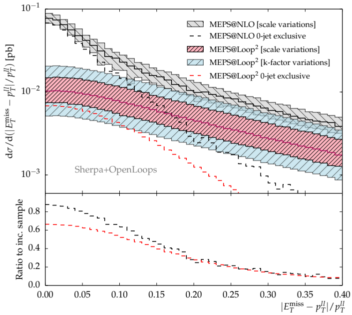
$pp \to Z\,H +$ jets production

- MEPS@NLO for $q\bar{q}$
  MEPS@LOOP^2 for gg
- care for $qg \to ZHq$:



$\to$ part of NLO ZHj
$\to$ in loop-induced as gauge inv. subset of NNLO ZHj

- loops from OPENLOOPS



$pp \to Z[\to \ell\ell\,]H[\to \text{inv}] + \text{jets}$

Higgs physics III

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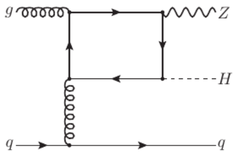

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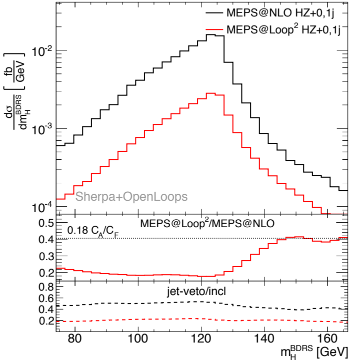


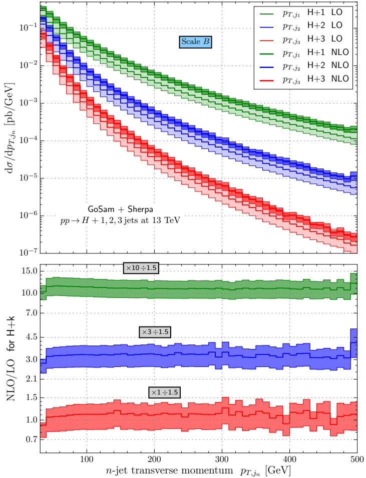
$pp \to Z[\to \ell\ell]\; H[\to b\bar{b}]$ + jets

Higgs physics IV

Greiner, Höche, L

$pp \to H +$ jets in ggF (HEFT)

- public NTuples for
  h1j, h2j, h3j @ NLO
  $\to$ fixed-order analysis
  GoSam interfaced for virtuals
- MePs@Nlo preliminary
  $pp \to h + 0, 1, 2, 3j$ @ NLO,
  $4, 5j$ @ LO
  produced for Les Houches '15
  detailed comparison



Higgs physics IV

Greiner, Höche, Luisoni, MS, Winter, Yundin arXiv:1506.01016

$pp \to H +$ jets in ggF (HEFT)

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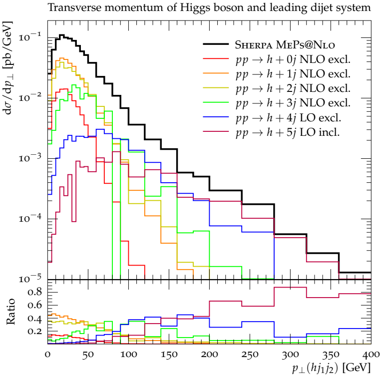


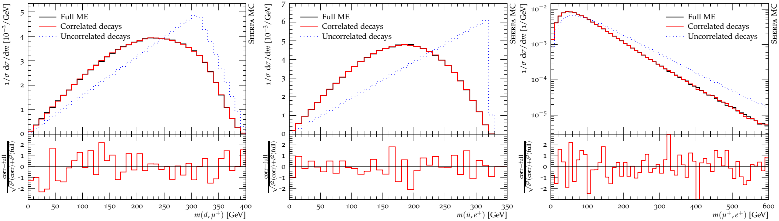
BSM physics

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
- automatic identification of all 1→2 and 1→3 decay channels of every unstable particle in the model
  → calculation of all decay widths (LO)
- per default all decay channel used
  → inclusive production
  → 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 physics

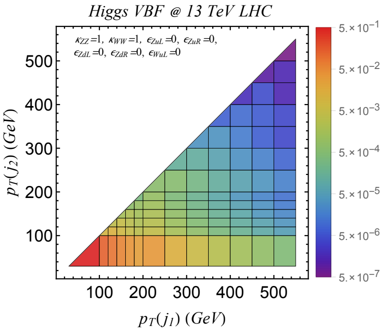
Höche, Kuttimalai, Schumann, Siegert EPJC75(2015)3,135

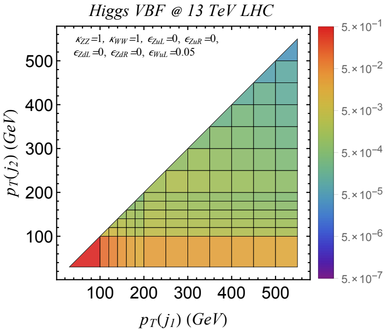


- simple three-step example:
  $pp \to \tilde{u}[\to d\chi_1^+[\to \chi_1^0 W^+[\to \mu^+\nu_\mu]]]\ \tilde{u}^*[\to \bar{u}\chi_2^0[\to e^+\tilde{e}^-[\to e^-\chi_1^0]]]$
- use truncated showers for QCD radiation off intermediate particles
- QED correction for each decay in YFS soft-photon resummation

BSM physics

VBF Higgs production in SM and BSM – $p_\perp$-correlation of tagging jets





Greljo, Isidori, Lindert, Marzocca arXiv:1512.06135

SHERPA-2.2.0

- supports UFO BSM format
- multijet merging for loop induced processes further tested, use as:
  - MEPS@LOOP^2
  - reweight MEPS@NLO Higgs production in HEFT with top mass dependence (only approx. in virtual corrections)
- a new parton shower DIRE
- on-the-flhy scale variations for ME part in LO, LOPS, MEPS, NLO, MC@NLO – MEPS@NLO coming in SHERPA-2.2.1
- new default PDF `NNPDF30_nnlo_as_0118`
- new tune of non-perturbative parameters
- a few interface changes
- there will be a bugfix release soon (SHERPA-2.2.1)

http://sherpa.hepforge.org

Thank you for your attention!