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Summary of meeting of Feb 12 and subsequent discussions/modifications

- As suggested by C. Reuschle we recommend to use Herwig's 7.1.2 angular ordered shower throughout and MC@NLO type matching for MatchBox simulations.

- Based on F. Siegert's suggestion we have adopted a more realistic lepton-isolation condition (already implemented and described above)

- M.V. Garzelli pointed out the need of a truncated shower for the case of angular ordering. T. Jezo diposes of a working implementation in PowhegBox.

- M. Zaro suggested to consider boosted observables. This is interesting and we should think about simple observables that provide insights into the boosted regime. Later on we should consider a dedicated boosted study with realistic top taggers, etc.

- M. Zaro pointed out that hadron decays generate additional leptons. However, now that lepton isolation is imposed we can safety stick to the requirement of exactly 2 oppositely charged leptons within acceptance. We may want to check that requiring 2 or >=2 leptons makes no significant difference.

- In principle one could investigate additional simulation layers:
    - splitting MPI and hadronisation
    - activating hadron decays
- In any case the present 3 layers (stable, parton-level decays, hadron level+MPI) should have the highest priority

- As requested by M.V Garzelli we have specified input values for the top- and W-widths.

- Maria Moreno Llacer pointed out that the input value Mb=4.75 GeV is outdated. At some point we should switch to the latest hxswg recommendation (4.92 GeV). However, before doing that we should address consistency issues with the values employed in ATLAS (4.95 GeV), CMS (4.8 GeV), in the PDFs (often 4.75 GeV) and in the showers. This decision is postponed, and for the moment we will stick to Mb=4.75 GeV.

- The choice of shower starting scale in MG5 remains to be discussed.

Summary of meeting of March 5 and March 19 and subsequent off-line discussions

Keep in mind: all results preliminary!

Available predictions

Tool	stable ttbb partons	decayed ttbb partons	decayed ttbb particles (stable hadrons)
Sherpa+!OpenLoops	ok (Sherpa)	ok	NEW
PowhegBox+OpenLoops	ok (PY8 updated, HW7)	ok (PY8 updated, HW7)	ok (PY8 updated, HW7)
MG5aCM@NLO	NEW	NEW	ok(PY8, HW7)
Powhel	ok (PY8)	todo	todo
MatchBox	ok (HW7)	todo	

Comments on the setup

- make sure you follow all recommendations as closely as possible, e.g. for shower versions and tunes, corresponding PDFs and alphaS values. Note that the recommended NNPDF30 nlo as 0118 nf 4 PDFs correspond to alphaS_5F(MZ)=0.118, which in turn corresponds to alphaS_4F(MZ)=0.112
- Sherpa: since version 2.2 the new default shower recoil scheme (for pure shower emissions) yields an enhanced jet activity wrt the previous default recoil scheme (used in YR4). The most appropriate choice for ttbb and the origin of the difference should be discussed.
- MG5aMC:
    - for a fully consistent comparison against Herwig's MatchBox we strongly recommend to use the angular ordered Herwig7.2.1 shower (done for ttbb stable, still HW++ for decays)
- Powhel: for PY8 the recommended version (see above) and the corresponding default tune with its own alphaS(MZ) value should be used (while setting Mb=4.75 GeV)

PDFs+alphaS values used for NLO, matching and showering

tool	Shower	1st H-subtraction	1st S-emission	>=2nd S-emission	>=2 H-emission
Sherpa+!OpenLoops	Sherpa	4F NLO	4F NLO	4F NLO	4F NLO
MG5aCM@NLO	PY8	4F NLO	5F LO PY8	5F LO PY8	5F LO PY8
MG5aCM@NLO	HW7	4F NLO	5F LO HW	5F LO HW	5F LO HW
MatchBox	HW7	4F NLO	5F LO HW	5F LO HW	5F LO HW
PowhegBox	PY8	none in Powheg	4F NLO	5F LO PY8	5F LO PY8
PowhegBox	HW7	none in Powheg	4F NLO	5F LO HW	5F LO HW
Powhel	PY8	none in Powheg	4F NLO	5F LO PY8	5F LO PY8
Powhel	HW7	?	?	?	?

In the MC@NLO framework we should address the issue of the consistency of the 1st S-emission and its matching counterterm (1st H-subtraction). In particular, using 5F LO PDFs+alphaS for the emission and 4F NLO PDFs+alphaS for its subtraction leads to a mismatch

- in the value of alphaS
- in the b-jet production rate: at O(alphaS) showering S-events with 5F PDFs generates tt+3b configurations for which there is no counterpart in the subtraction term

Legend

- 4F NLO = 4F NNPDF30_nlo_af_0118 4F (used for NLO calculation)
- 5F LO PY8 = 5F NNPDF2.3 QCD+QED LO (Monash tune PDFs)
- 5F LO HW = 5F MMHT14 LO (HW tune)

Corresponding values of strong coupling

	4F NLO	5F NLO	5F LO HW	5F LO PY8
alphaS(MZ)	0.112	0.118	0.126234	0.13650
ratio to 4F NLO	1	1.054	1.125	1.219

Choice of the shower starting (scalup) in MC@NLO tools

Given as input scale muQ the various tools set scalup as follows

tool	scalup_mean for S-events	scalup_max for S-events	H-events
MG5	muQ*(1+0.1)/2	muQ	muQ
Sherpa	muQ	muQ	kT of 1st emission
MatchBox	muQ*(1-0.3)	muQ	muQ'*[1-0.6,1]

Comments

- In MG5, for the showering of S-events, scalup_S is distributed between [0.1,1]*muQ, while H-events are showered with scalup_H=muQ
- In Sherpa H-events are showered by setting scalup_H=kT of 1st emission (independent of muQ)
- Note that also in Powheg the finite remnant (analogous to H-events) is showered with scalup_H=kT of 1st emission
- In Herwig scalup_H and scalup_S are distributed according to a "resummation profile" [3] that ranges between [1-2*rho,1]*muQ, with default width rho=0.3, i.e. scalup_mean=0.7*muQ;
- For H-events in Herwig, muQ' is computed including also the ET of the 1st reconstructed jet in the definition of HT/2 Relevant Herwig references (suggested by C.Reuschle and S. Plaetzer): [1] https://arxiv.org/abs/1705.06919, [2] https://arxiv.org/abs/1512.01178, [3] https://arxiv.org/abs/1605.01338,

The above choices may be responsible for the observed differences. Their motivation and impact should be discussed in detail

The following technical studies for (mainly for MC@NLO tools) are recommended

- separate contributions form S/H events and quantify their relative weight to check if MC differences arise from regions dominated by S or H events
- Study variations of scalup_H and scalup_S separately to find which one dominates (reducing scalup_H in MG5 was found to augment the enhancement. This suggests that S-events dominate and H-events tend to be negative)
- synchronise scalup choices as much as possible to understand if differences are mainly due to matching choices or to the shower itself.

Enhancements in the jet-pT spectrum can be explained with three possible mechanisms:

- By large NLO K-factor entering S-event weights (in regions where S-events tend to dominate)
- As side effect of the shower recoil, which can kick b-jets above the threshold resulting in migrations from bins with low to higher b-jet multiplicity. This hypothesis can be checked by studying the jet-pT distribution in the absence of b-jet acceptance cuts (to be added to the Rivet analysis)
- The different impact of g-> bb splittings in different showers. This can be checked by switching off g->bb splittings in the parton shower (to be studied for stable ttbb only).

Choice of scalup labelling scheme in MG5 and MatchBox

tool / comments	scalup_mean	scalup_max	hxswg plots label	yoda's label	comments
MG5: alternative choice	HT/2	HT	(0.5,1)*HT	2ht	shown after March 5 meeting, labelled as HT/2
MG5: default proposed by authors	HT/4	HT/2	(0.5,1)*HT/2	ht	new nominal prediction since Match 19 mtg
MG5: further available variation	HT/8	HT/4	(0.5,1)*HT/4	hto2	shown in March 5 meeting, labelled as HT/2
MatchBox	0.7*HT/2	HT/2	(0.7,1)*HT/2		

Rivet analysis

- An extra version of the lepton-pT distributions without lepton isolation was added
- It was proposed scalup should be added to the rivet analyses
- A new version of the light-jet pT distribution in log scale up to 1 TeV was added

Fixed-order predictions (new)

- Optionally, as a sanity check, we recommend to provide also fixed-order NLO results for the analysis with stable top quarks
- Inclusive NLO XS

tool	Powheg+PY8	Powheg+HW7	Sherpa	Powhel	MatchBox	MG5+PY8	MG5+HW++	MG5 integrati
XS[pb]	26.48 +- 0.08	26.55 +- 0.01	26.63 +- 0.1	27.53 +- 0.1	26.36 +- 0.3	25.72+-0.06	25.96 +- 0.05	26.15+-
ratio-1	-0.003 +-0.003	0.000 +-0.000	+0.003 +-0.004	+0.037+-0.004	-0.007+-0.012	-0.031+-0.002	-0.022+-0.002	-0.015+

Comments:

- errors in this table are copy-pasted from the Yoda files and are not realistic
- the Powhel result is still about 4% higher due to a radiation-dependent scale choice in the subtraction terms. New NLO and NLOPS predictions with a consistent Born-like scale choice in the counterterm will be generated.

Issues with HWG7

- In the case of decaying tops it was found that the lepton pT spectra predicted by MG5+HWG7 deviate quite strongly from MG5+HW++. This is probably due with an issue with top decays in HW7. It was suggested to try the spin-correlated version of top decays in HW7.
- At the moment MG5+HW predictions are based on HW++ for the case of decaying tops and HW7 for stable tops. In the latter case the matching is done with HW++ subtraction terms. Due to the different recoil schemes in HW++ and HW7 this is not entirely consistent and should be fixed.

Next steps before plenary meeting

- Everybody but only for stable ttbb analysis
    - update analysis from svn (now including also jet-pT and ttbb-pT spectrum without b-jet cuts) and regenerate default predictions
    - repeat analysis switching off g->bb splittings in the shower
- Everybody (optional)
    - separation of S/H events in MC@NLO matching
    - unless already done: factor-2 variations of resummation scale (in MC@NLO matching) and hdamp (in Powheg matching)

- Powhel
    - fix issue in scale choice for subtraction terms
    - deliver missing predictions
- MatchBox
    - deliver missing predictions
    - provide details on PDF+alphaS used for showering
- Sherpa:
    - clarify definition of starting scale in H-events

Plots for HXSWG plenary meeting (March 26, 2018) (remember to refresh your browser)

Stable ttbb production:

- nominal NLOPS predictions and ratios wrt Sherpa all plots selected plots
- nominal NLO+PY8 and ratios wrt Sherpa all plots selected plots
- nominal NLO+HW7 and ratios wrt Sherpa all plots selected plots
- NLO+PY8/NLO+HW7 ratios (tool by tool) all plots selected plots
- relative effect of double g->bb splittings (tool by tool): sigma/sigma(g->bb off in PS) all plots selected plots

Stable ttbb production: muQ and hdamp variations

- all tools all plots selected plots
- Sherpa all plots selected plots
- MG5+PY8 all plots selected plots
- MG5+HWG all plots selected plots
- PowhegBox +PY8 all plots selected plots

Decayed ttbb:

- nominal parton-level NLOPS predictions and ratios wrt Sherpa all plots selected plots
- relative effects of hadronisation+MPI+QED shower tool by tool all plots selected plots

Open questions and next steps discussed at April 16 meeting

(page numbers refer to the slides presented at the meeting)

General observations that may explain MC differences

- The local K-factor that enters the NLOPS matching procedure is quite large: K=1.9 (see p.8)
- Hypothesis: MC differences may arise from the interplay between the large local K-factor (applied to S-events), the differences in the S/H separation, and b-jet bin migrations induced by jet-recoil effects (see p.8, 11 and 24)
- The only irreducible difference between Powheg and MC@NLO lies in the approximation used for soft/collinear radiation: parton shower (in MC@NLO) or matrix element (in Powheg), while the profile function used to separate S/H terms can (at least in principle) "synchronised" (see p.11)
- For a while we propose to restrict further studies to parton-level ttbb production w.o. hadronication/UE (p21)

Sherpa recoil scheme (p7)

- the change in the default Sherpa recoil scheme from v2.1 to v2.2 has a significant impact. The Sherpa authors should provide some details on nature an motivations behind these recoil schemes.
- Shall we regard the difference as uncertainty?

Scalup-S profile (p17a)

- In order to test if the MC differences arise from the S/H separation, a narrower profile for the S/H separation should be used throughout (both in MC@NLO and Powheg matching)
- Contributions from S and H events should be separated in order to check if S/H shape differences are consistent with the observed MC differences
- Jonas will try to implement an on-the-fly separation of S/H events through the Rivet analysis

Scalup-H profile (p17b)

- The Sherpa authors should clarify the choice of starting scale for H-events

PDF choice for showering in the MC@NLO approach (p19)

- MC@NLO matching to PY8 with Monash tune implies a very large value of alphaS (0.1365) for the 1st emission in S-events
- As a purely technical check, in order to assess the effect of the large alphaS value, one should compare the default MC@NLO+PY8 predictions against alternative ones where the Monash-tune PDFs (5F NNPDF2.3 QCD+QED LO) are replaced by PDFs of the same NNPDF release but with alphaS(MZ)=0.118 and, alternatively, alphaS(MZ)=0.130. The shower should employ the alphaS value taken from the actual PDFs (it is not entirely clear whether this is the case by default). Top quarks should be kept stable. (The results should be interpreted keeping in mind that changing alphaS+PDFs can mess up certain aspects of the tune).
- Later we should try dedicated PY8 tunes based on ttbar data, which feature more reasonable alphaS values
- What about Herwig?
- The relation between alphaS and the tuning of other parameters should be clarified with the PY8 authors. A tune with alphaS(MZ)=.118 would be desirable.

hdamp in Powhel (p22)

- The Powhel authors will consider the option of extending the hdamp separation to FSR

New Rivet analyses targeted at B-jets from g->bb splittings (p24)

- we have introduced new variants of the Rivet analyses targeted at jets with > 1 b-quark constituent (denoted here as bb-jets):
    - Hxswg_ttbjets_stable_v2 = standard analysis with cuts+observables in terms of usual b-jets (with one or more b-quarks inside)
    - Hxswg_ttbjets_stable_v2_0bb = same with extra veto against events with bb-jets
    - Hxswg_ttbjets_stable_v2_1bb = standard analysis with usual cuts+observables applied to bb-jets plus extra requirement of exactly one bb-jet
    - Hxswg_ttbjets_stable_v2_2bb = same as "1bb" but requiring exactly two bb-jets
- In practice you should just update the usual hxswg_ttbjets_stable_v2 analysis from svn and compile it. This will generate hooks for the four parellel analyses that all have to be requested in Rivet during event generation

From now on, please always run these 4 analyses in parallel.

muQ dependence (p28)

- Sherpa features a counter-intuitive muQ dependence that should be understood: the "excess" in the light-jet pT grows/decreases when muQ is reduced/increased.

-- StefanoPozzorini - 2018-02-09

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