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Theory systematics

Signal (ttbar and single top) TH systematics

Note that this page is outdated as of January 2019. Information on currently used TH systematics can be found in the ATLAS and CMS papers.

- **Generator modeling**: comparison of central predictions from generators. Other sources not ending in one of the following categories and specific to a certain analysis may end up here (example: DR vs DS scheme for ttbar subtraction in Wt). General guidelines suggest to use for the ttbar signal at least one multileg generator and at least one NLO generator, and for single top at least two different models (one of which NLO). Differences coming from the use of different (tuned) PS models can also end up in this category whenever it is clear this is not already covered by the explicit systematic error on the description of radiation (and hadronisation).
    - to be discussed: do we want to leave this error optional, only for when the difference between the two predictions goes outside the band from the error on radiation (and hadronisation)?
    - some authors advice, for observables at NLO precision, to also quote the uncertainty from interfacing the prediction to two different parton showers. While this is a conservative approach, it is under discussion how to quantify the amount of double counting of the uncertainty coming from hadronization effects.
    - other authors claim that different NLO-PS matching scheme should be compared (e.g. MC@NLO vs Powheg). It is uncertain whether the difference should be quoted as an extra systematic uncertainty on top of the rest.
- **Radiation description**: Q^2 and I/FSR independent variations (to be agreed for NLO generators) or Q^2+PS consistent variations (for matched generators). ATLAS Run I analyses in some cases use LO generators not using multi-leg processes/matching. With Q^2 we indicate both renormalization and factorization scales, ideally changed in an independent way. The suggested variations are conservative and correspond to a factor 0.25 and 4 (1/2 and 2 on Q) or constraints on the variations from the data when available. While the procedure for estimating this error is conceptually the same whether an NLO tool or a matched generator are used for describing the signal, procedural differences from the guidelines of the various authors may be present.
    - Both ATLAS and CMS will quote this source, likely determined in a different way.
    - the (POWHEG-BOX, MC@NLO) author recommendations on variations to be used for NLO generator are (as of present) to use independent ren. and fact. scale variations in ME and further uncorrelated variations of ren. scale on the PS side. The recommended procedure will possibly be updated after further studies and discussions. ATLAS and CMS will use the recommendation subject to sample production capabilities in

the absence of relevant NLO generator versions that enable renormalization and factorization scale reweighting. To discuss: in the case of NLO generators, the ren/fac uncertainty is likely best quoted as a separate category.
    - Homework for ATLAS and CMS: whenever possible use top data to constrain these variations.
    - To be discussed further: how to count for different functional forms of the scales with respect to kinematics?
- **Matching between ME and PS** change matching thresholds, applicable only for matched generators. Thresholds should be "sufficiently" away from zero and "much smaller" than the process scale. The extreme of the variation range should be such that the good properties of the matching are checked to still hold (differential jet rates, and other differential cross sections, continuous with continuous derivatives after the matching)
    - Experiments will quote this uncertainty only if the reference generator for the signal is a ME-PS matched one.
    - Homework for ATLAS and CMS: whenever possible use top data to constrain these variations.
- **Underlying Event**: different UE tunings or different fractions of semi-hard MPI interactions. Currently, the comparison is typically done with Pythia6 tunes.
    - Both ATLAS and CMS will quote this source
    - To discuss: consider the P12-ueHi,P12-ueLo tunes available in Pythia6 versions from 6.428 on-.
- **Colour Reconnection**: compare tunes with/without a CR model. Currently, the comparison is typically done with Pythia6 w/wo CR tunes.
    - Both ATLAS and CMS will quote this source
    - Homework for ATLAS and CMS: whenever possible use top data to constrain these variations.
    - To discuss: the noCR tunes are in tension with the UE and CMS top data. We should consider other (Pythia) tunes. e.g. PYTUNE:374, P12-loCR, which is intended to give a less extreme option for variation than the "noCR" one.
- **Hadronization**: compare at least two different hadronization models. Currently, the comparison is typically done between fortran Pythia and fortran Herwig. Care should be given that the reference tuning used are consistent with each other. In particular, when possible, the data used for tuning and performance for the tuned observables should be comparable.
    - To discuss if both ATLAS and CMS will explicitly quote this source
- **PDFs**: proper eigenvalues envelop to be propagated to the error. It is recommended to use NLO PDF with NLO generators.
    - under discussion: should full LHC4PDF prescription only for those analyses demonstrated to be very sensitive to the description of the PDFs?
    - Both ATLAS and CMS will quote this source
- **Top mass**: depending on the measurement, this can be quoted as a systematic error or not. For this, the top mass has to be varied in the generation and an error corresponding to the current experimental uncertainty propagated to the final observable. For observables that are strongly dependent on the top mass (e.g. the

total cross sections) it is preferred that both CMS and ATLAS quote the measurement at the world average value and present the dependence on the measurement on the top mass (typically due to the change of the acceptance with the top mass itself) for possible future extrapolations.
    - Both ATLAS and CMS will quote this source

Background TH systematics

- **Generator modeling**: as above, where applicable. The impact of the heavy flavour treatment in bosons+jets should enter this category.
    - Both ATLAS and CMS will quote this source
- **Radiation description**: as above
matched calculations, hence by implementing consistent Q^2+PS variations
    - Both ATLAS and CMS will quote this source
    - Homework for ATLAS and CMS: whenever possible use top data to constrain these variations.
- **Matching between ME and PS**: change matching thresholds in the setup, as described for the signal. The range of variation is obviously process dependent.
    - Both ATLAS and CMS will quote this source

Other to-dos/proposals

- The full generator cards and PS setups, as well as the generator versions used for the systematics should be public, such that the samples are in principle reproducible for a person not internal to an individual experiment. The TOPLHCWG twikis are likely the right places where to put this information: ATLASCMSGeneratorCards .
- ATLAS and CMS will aim to provide Rivet implementations for their analyses, when they are likely to be useful for constraining the theory systematics.

Papers and notes with ATLAS and CMS theory modelling info

Please have a look at ATLAS top public results and CMS top public results pages for more and guaranteed to be up-to-date information.

Descriptions and comparisons of generator setups used by ATLAS and CMS:

- ATL-PHYS-PUB-2014-005: Comparison of Monte Carlo generator predictions for gap fraction and jet multiplicity observables in top-antitop events
- ATL-PHYS-PUB-2013-005: Monte Carlo generator comparisons to ATLAS measurements constraining QCD radiation in top anti-top final states
- CMS-CR-2013-417: Signal modeling uncertainties in top quark production

-- RobertoChierici - 05-Apr-2012

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