LH 2019: "MC uncertainties" discussions

Emanuele Re

CERN & LAPTh Annecy

"HXSWG: Parton Shower Uncertainties in Higgs Measurements"

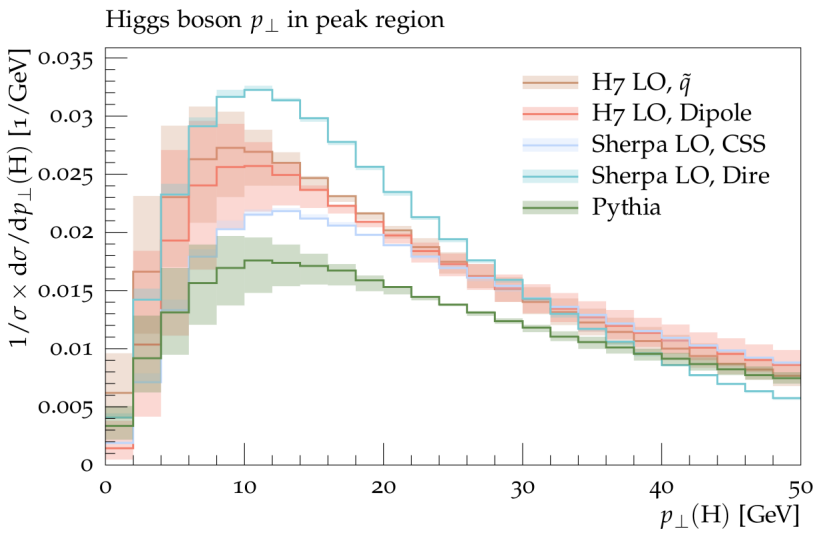
CERN, 27 June 2019

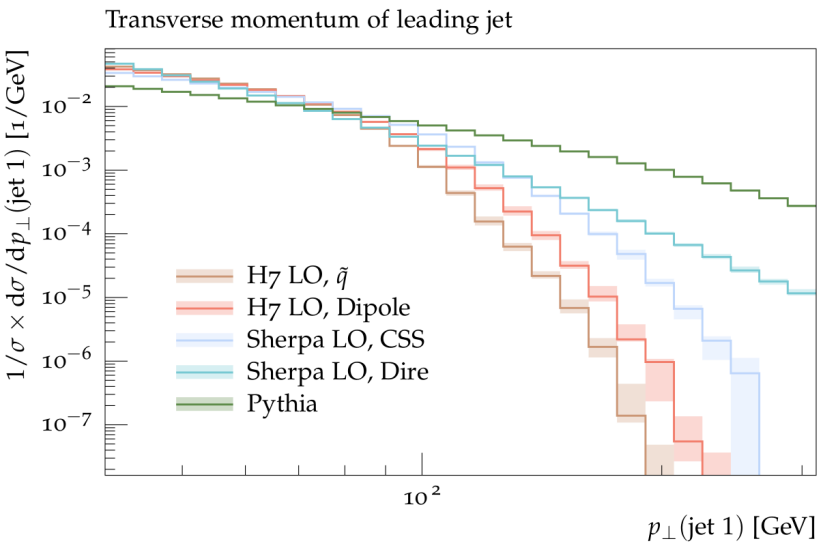
disclaimer

- following slides: attempt to summarize what was discussed in LH and present it in an orderly manner.
- not an easy task. In the following, for sure there's some bias and some personal interpretation of the various ideas, suggestions, requests.

status - TH

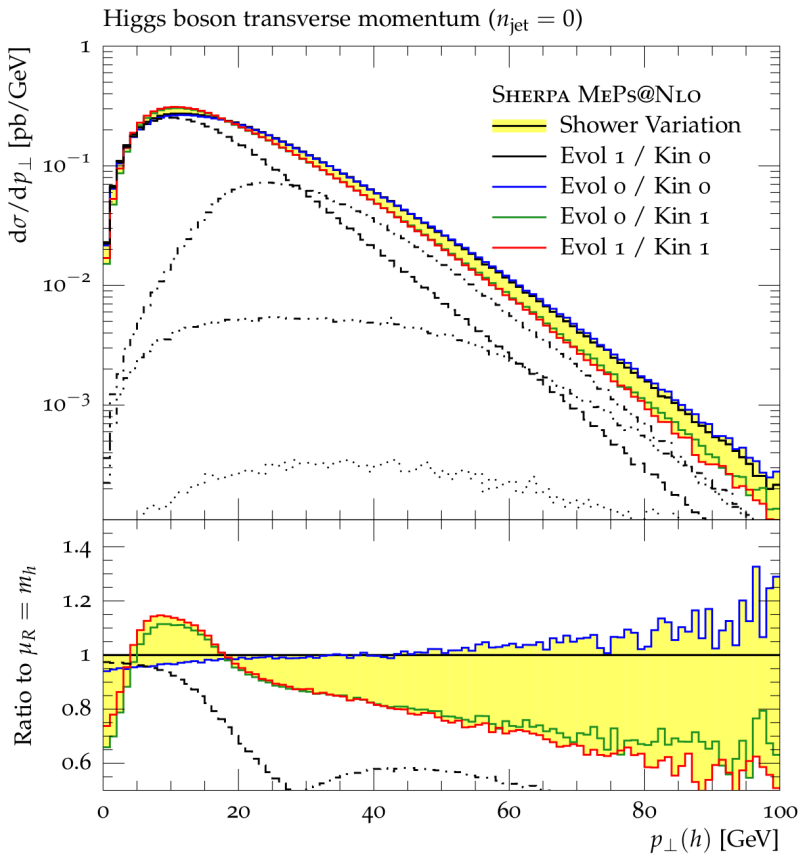
- discussions about the estimation of uncertainties in PS have been a recurring theme since LH15





status - TH

- discussions about the estimation of uncertainties in PS have been a recurring theme since LH15
- by now more studies exist, but an “agreed procedure”, as in FO computations, seems to be missing so far



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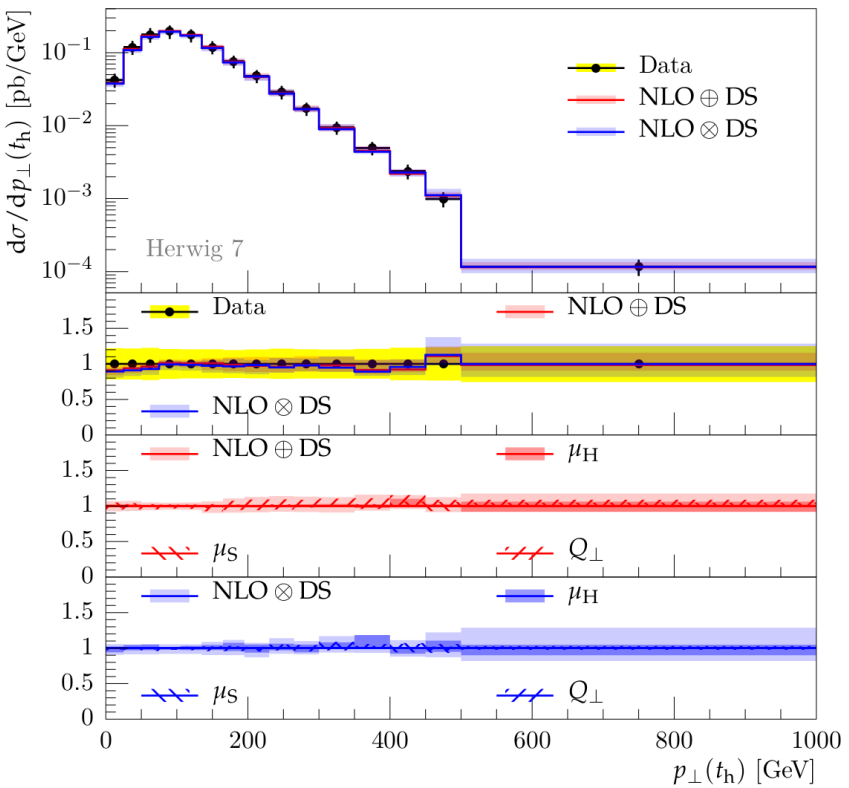


1810.06493

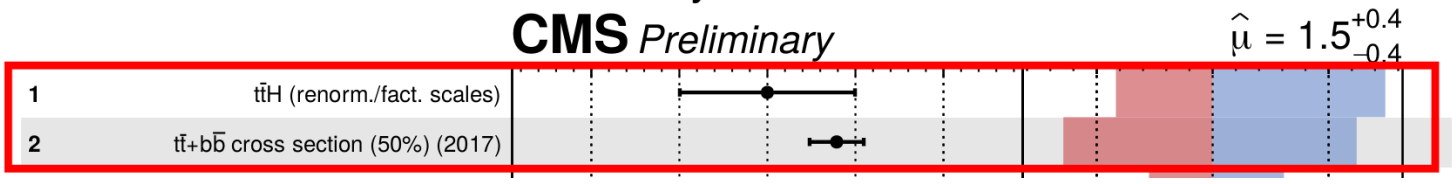
- similar studies for top mass also in [Ferrario Ravasio et al, 1801.03944]

status - TH

- (I think it is) fair to say that, at the moment, in the TH community, there's no overall solid consensus on how parameters should be varied in PS (and to which extent different variations should be correlated)
- Ultimately, this is due to the fact that PS deal with scale hierarchies and they are only LL accurate
- On top of this, there are also uncertainties related to the modeling of the NP part (hadronization, UE/MPI, ...)

status - EXP

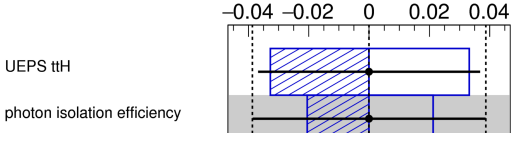
- this situation clashes with the EXP needs, particularly when the “MC uncertainty” is the main TH systematics
  - Single **sources of uncertainty with largest impact**
    - Signal cross-section: artefact of measuring signal strength $\mu = \sigma/\sigma_{\text{SM}}$
    - $t\bar{t} + b\bar{b}$ cross-section uncertainty



(from EXP talk by M. Schröder on Tuesday)

- main EXP request: a TH-agreed procedure to use to evaluate “MC uncertainties”, with recommendation on what parameters to vary and in which range.
  - (I think we are) not there yet, but, as I have shown, dedicated studies that go in this direction exist
- TH perspective: at times, the procedures currently used by EXP are not very transparent, or not very well documented, or not ideal, e.g.:

- not always “variation X” has the same exact meaning in different tools
- What does “UEPS” mean ? (e.g. ATL-PHYS-PUB-2018-054)
- uncertainty = LO+PS vs NLO+PS ?



- out of these discussions, 2 main projects were suggested

project 1: “nomenclature”

Discuss what parameter variations are possible in General-Purpose MCs: this should help build an intuition on which of these variations can affect which measurements.
In practice

- as comprehensive as possible list of all possible variations available in each generator
- list of correlations among these variations (as comprehensive as possible)
- for each MC:
  - exact interpretation of name “variation X”, and which phenomena it influences
  - what are the constraints when varying parameters that should not be broken
  - wherever this is possible, suggested ranges of variations
  - disclaimers and “good practice”

Aims:

1. common naming convention
2. list of examples with (category of) MC variations that are relevant in each case, possibly with plots.
   - bare lepton $\rightarrow$ QED shower
   - small-R jet $\rightarrow$ hadronization more relevant than MPI, opposite for large-R jets
   - ...

   EXP: not clear this categorization is useful in practice.

To be effective, need of having all MC developers: suggested to coordinate during MCnet meeting.

project 2: “test case”

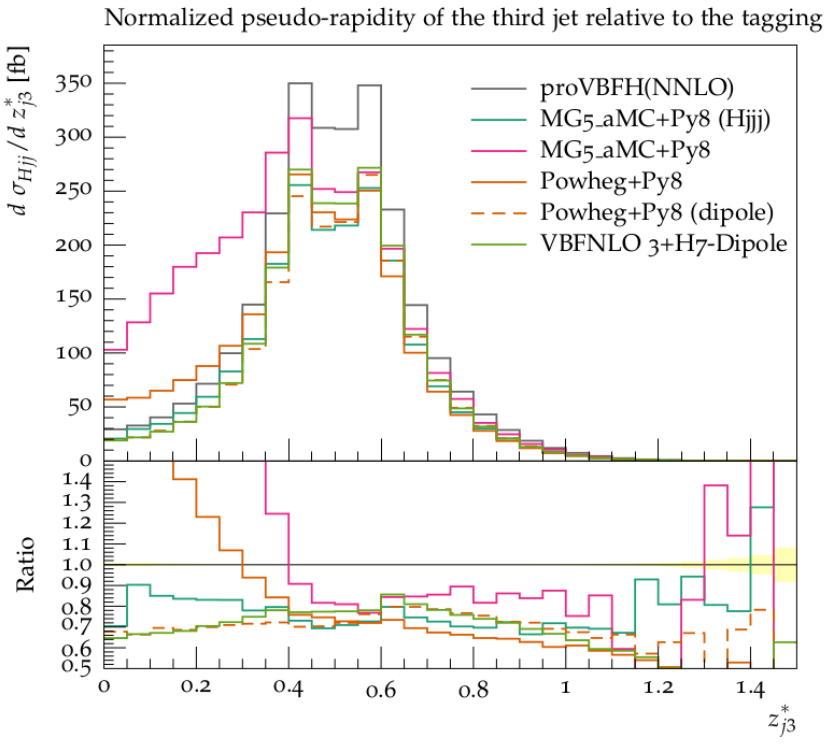
Study MC variations as consistently as possible from the TH viewpoint, as if one were to use them in an analysis. If possible, use the agreed naming conventions.
In practice:

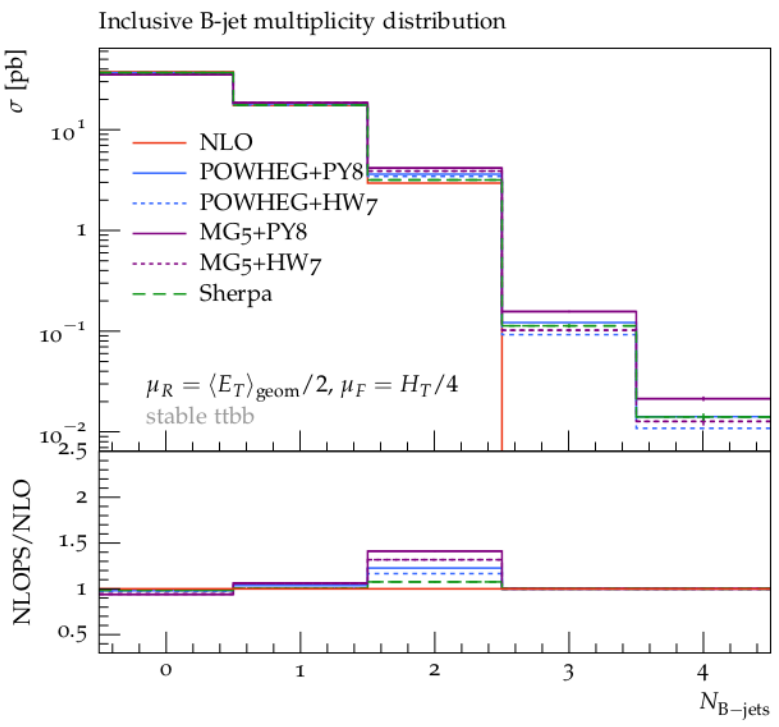
- consider 1 case study, select 2-3 observables, perform (a selection of) MC variations
- produce an envelope for a given setup X:
  X={(FO/matching/merging accuracy), PS model, NP model}
- check if the envelope from setup X behaves as expected or not:
  - for instance, does it happen that in a region that should be dominated by “hard physics”, one has a residual dependence upon the NP model, or a too-large dependence upon some shower parameters?
- check if envelopes from setup X_i and setup X_j overlap:
  - If there are very large differences, is this expected (given the kinematic region probed and the perturbative/non-perturbative content of the setups)?

- Continuation of what was done in LH15 (1605.04692)
- nowadays: higher accuracy in the ME part, better frameworks for “PS-reweighting”
- chosen $t\bar{t}$: NLO+PS not too computationally intensive, rich phenomenology, plenty of ATLAS/CMS studies with very similar setups, data and Rivet routines available, some TH studies already performed (e.g. HW7, 1810.06493)

project 2: “test case”

- (to me) this approach seems suitable to highlight issues, if there (as done in the context of the HXSWG for VBF and $t\bar{t}H(\to b\bar{b})$).





- it should also clearly show that, unless unavoidable, it’s not a good idea to estimate an uncertainty comparing a LO+PS vs. NLO+PS generator.
- it also seems to go towards what the EXP community is asking for.