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# Phenomenology issues: MadGraph5_aMC@NLO

ATLAS-CMS MC meeting

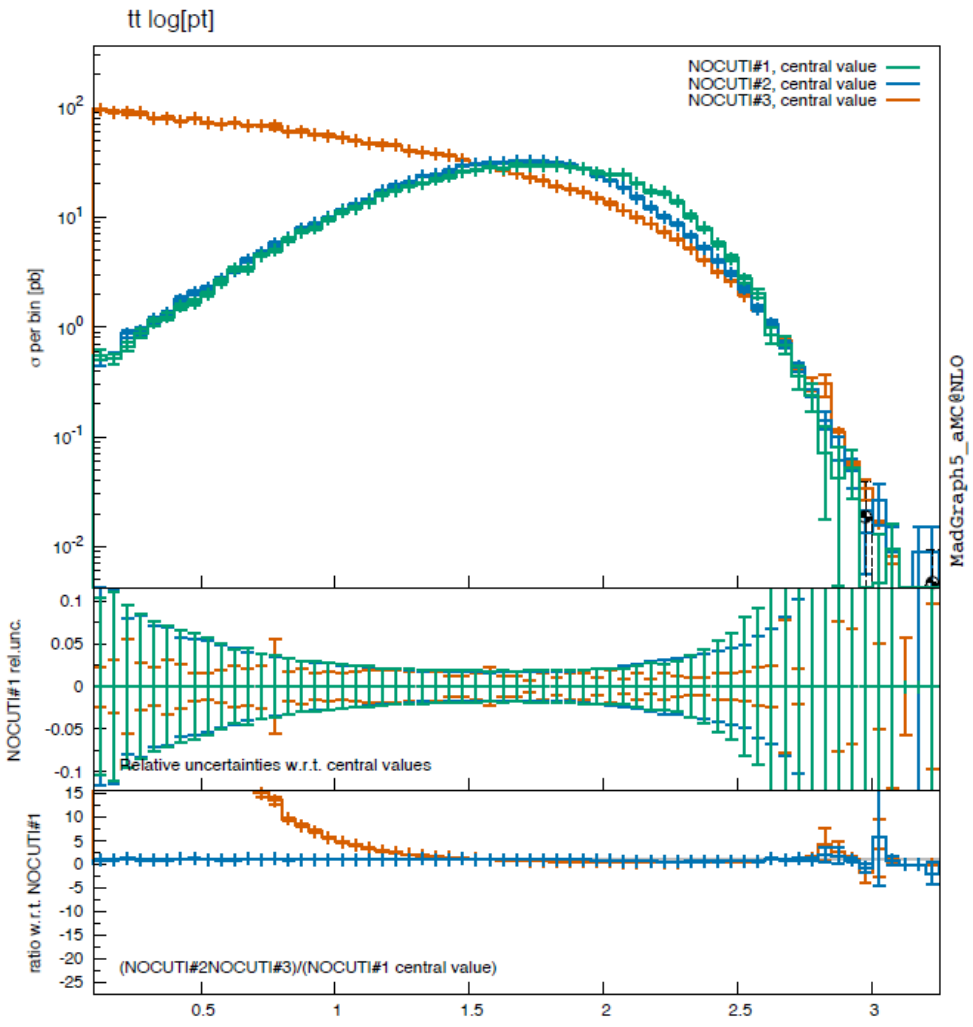
CERN, 3/5/2017

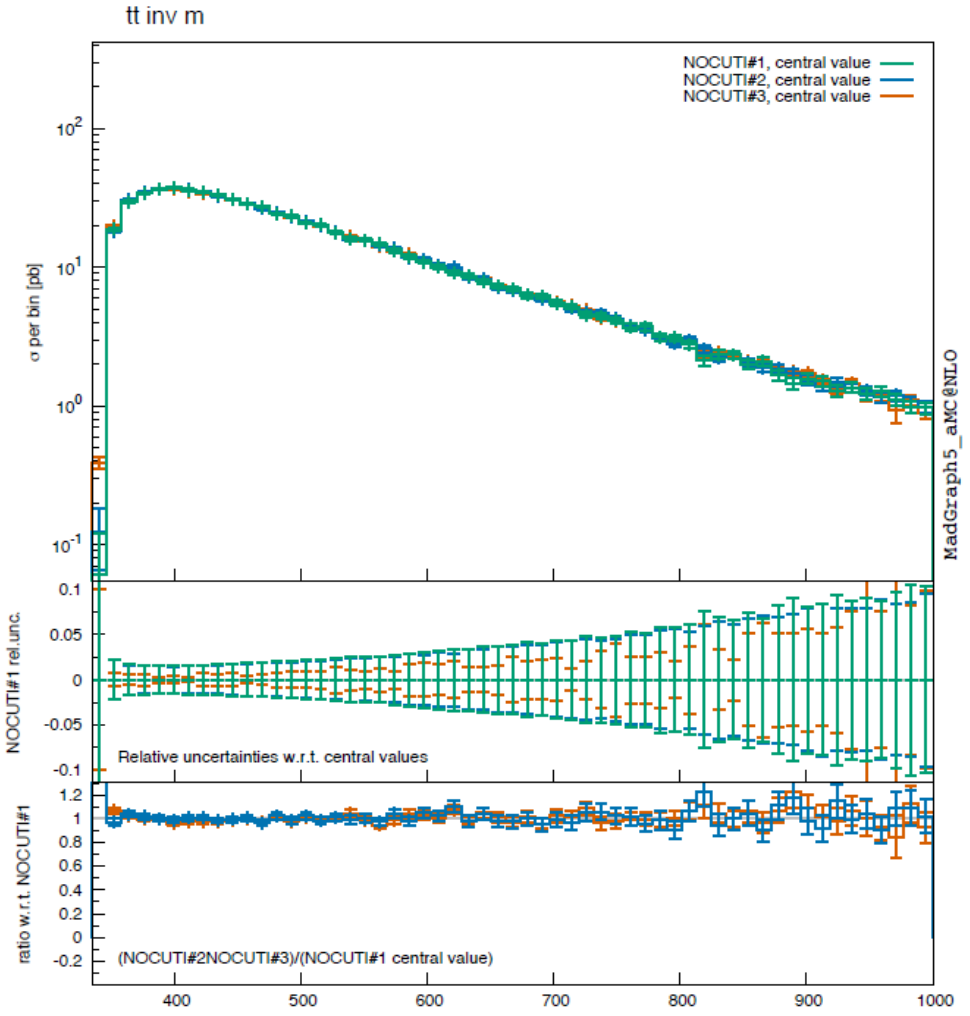
I will only very briefly discuss what I consider to be urgent problems:

- Comparisons to $t\bar{t}$ data
- Refined treatment of resonances
- $gg \to H+$jets

# Shower reference scale

- v2.5.3 features a new default shower reference scale ($\sqrt{\hat{s}} \longrightarrow H_T/2$)
- It is important to have data that support this (or any other) choice (incidentally: this is *not* the case for $t\bar{t}b\bar{b}$)
- The differences induced by any two scales *may* be large only in MC-affected regions
- See e.g. our tests for $t\bar{t}$ production $\longrightarrow$




Blue: $\mu_0 = H_T/2$

Green: $\mu_0 = \sqrt{\hat{s}}$

Red: fNLO

Ignore the ratio plots

These parton-level findings are seemingly similar to those of ATLAS

ATLAS hadron-level $M_{tt}$ results for the two scales are visibly different

This is very disturbing

- Problems in MC/Rivet?
- A less than ideal definition of what is meant by "top"?

We need to understand this before proceeding with time-consuming operations (e.g. MC tuning)

# In general, for $t\bar{t}$ simulations vs data

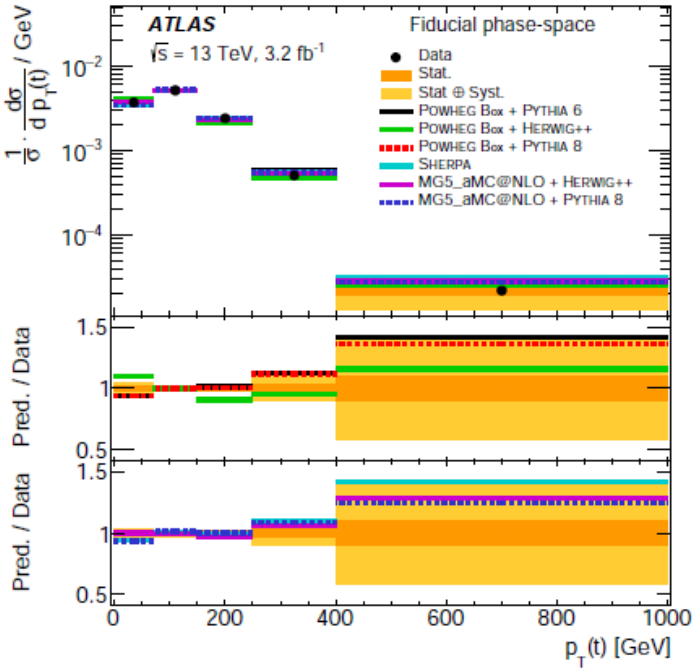
- The situation with data/theory comparison for $t\bar{t}$ production is somehow confusing (possible inconsistencies; different simulations [eg inc vs merged], different final-state objects)

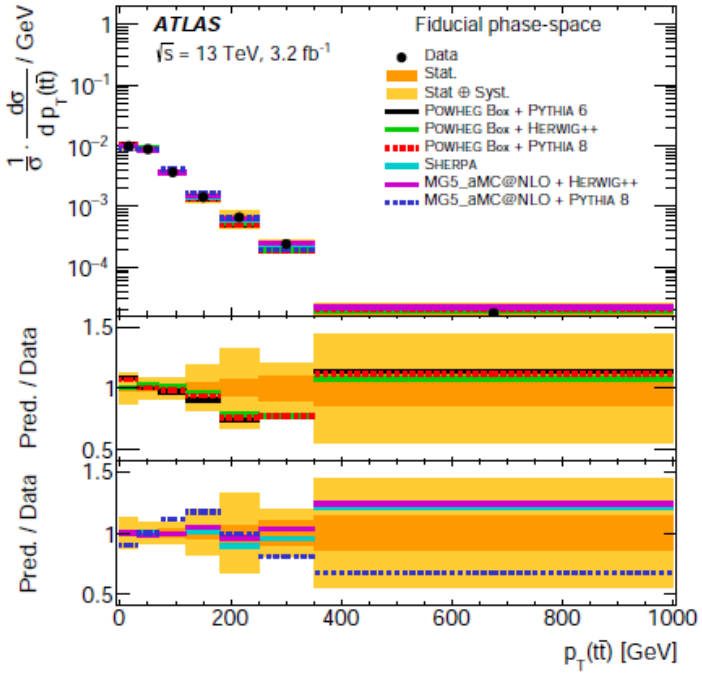
(at least, confusing for me). Eg, this morning at SM@LHC 

## ATLAS Differential $t\bar{t}$ cross section at 13 TeV: dilepton

arXiv:1612.05220 (EPJC acc.)

- Dilepton: need to reconstruct 2 neutrino momenta to calculate top/$t\bar{t}$ observables
- Differential top cross sections at particle level: top proxy and $t\bar{t}$ system



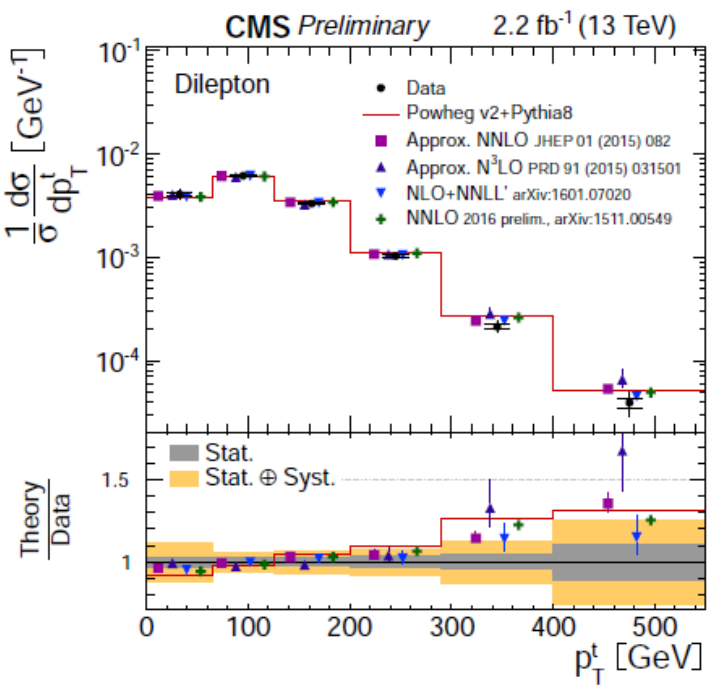

- Good agreement found with MC predictions, with the exception of Powheg+Herwig++ for top $p_T$ and $m_{t\bar{t}} \rightarrow$ compatible with other measurements?

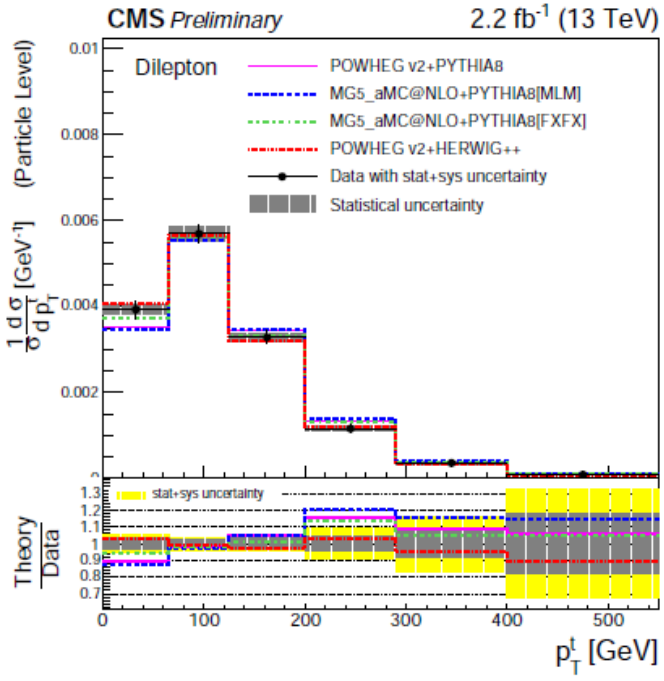


Note the Powheg+Herwig++ bit

## CMS Differential $t\bar{t}$ cross section at 13 TeV: dilepton PAS-TOP-16-011 PAS-TOP-16-007

- Measured top/$t\bar{t}$ observables at parton and particle level




- Top $p_T$ best described by Powheg+Herwig++
- Found good agreement with NNLO at parton level



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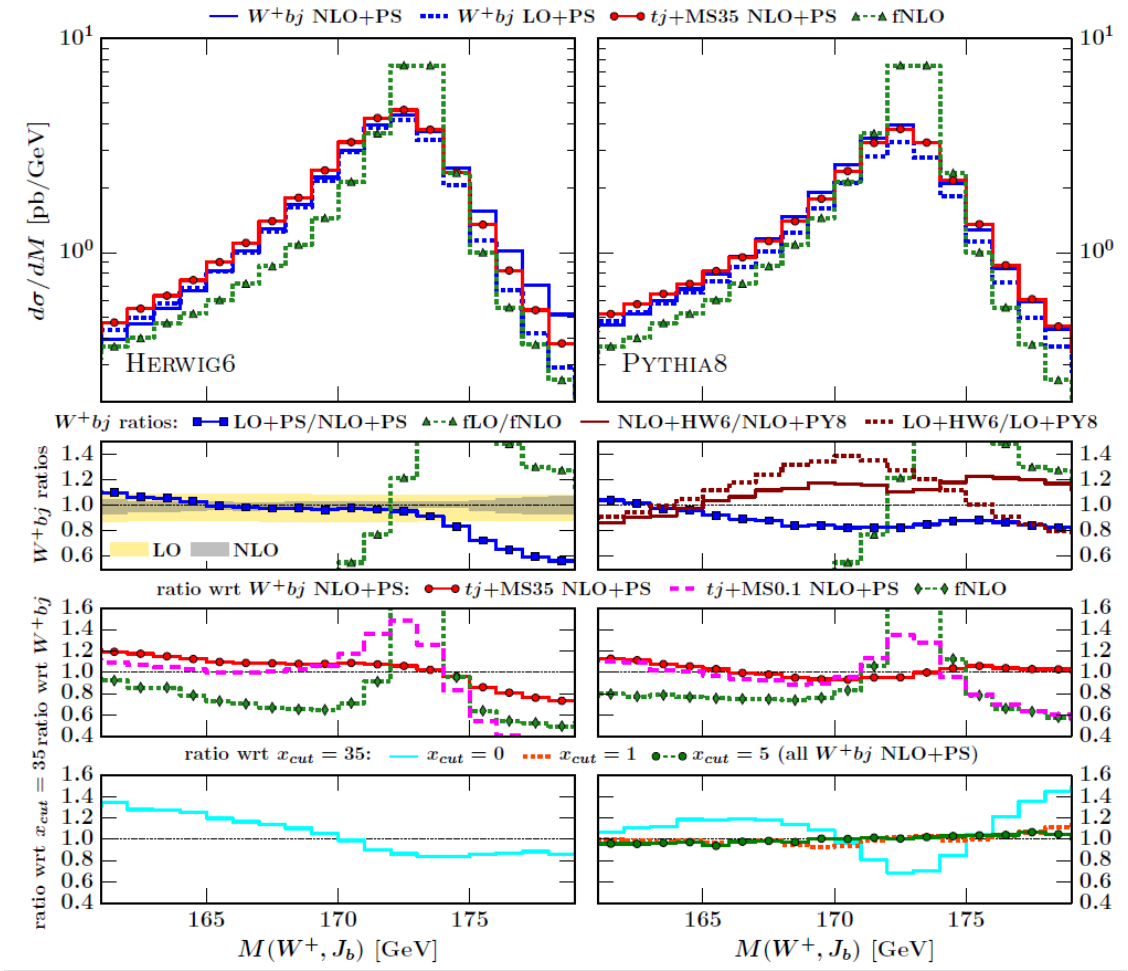
- But (and this is not contradictory): beyond a certain level of precisions, tunes are necessary, and generator-specific
- E.g.: as you tune `hdamp`, you might tune the shower reference scale (I'm not saying you should; other MC parameters must be tried first)

## Forgotten/barely used

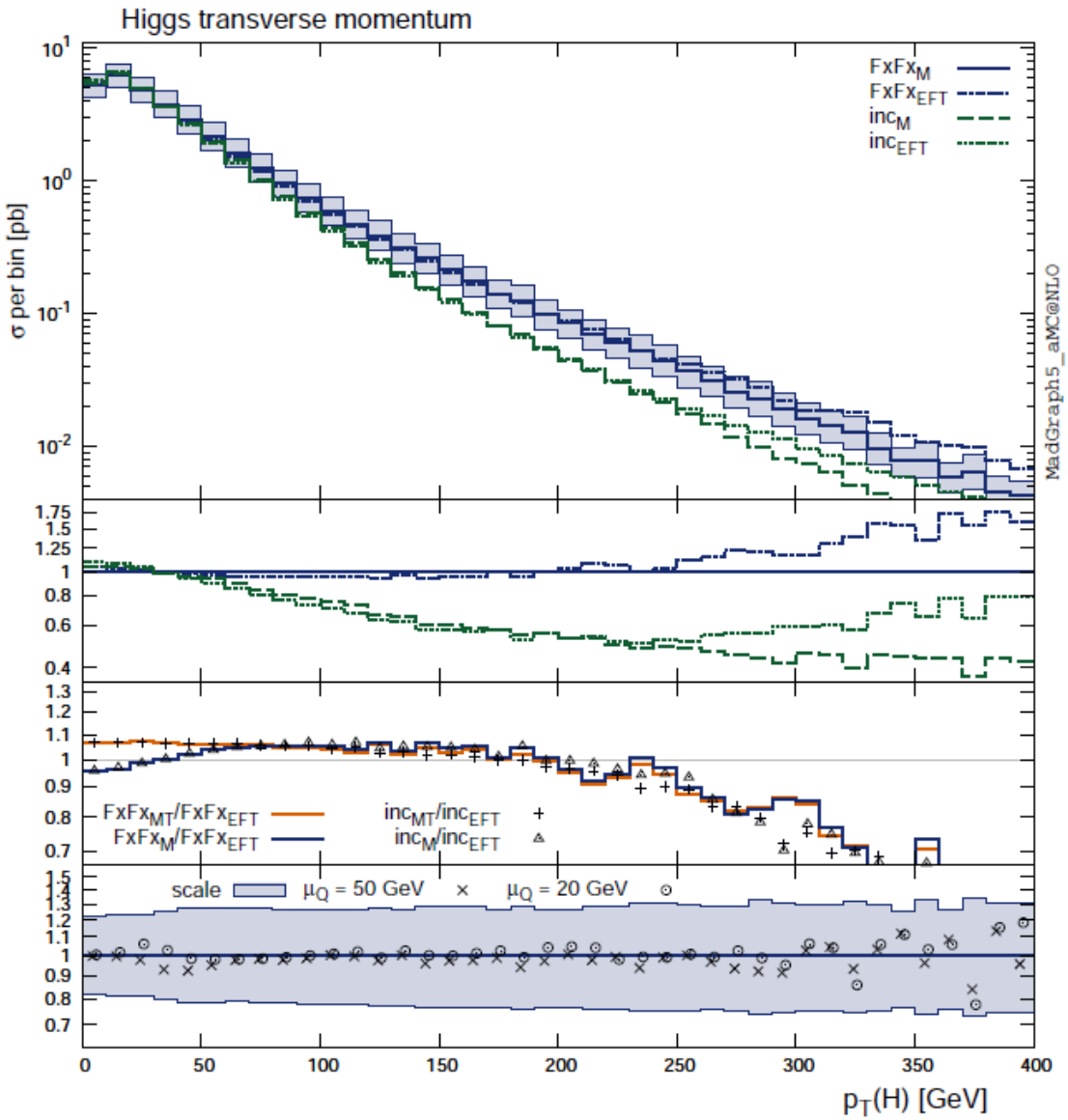
- In 1603.01178 we have shown how to improve the treatment of coloured resonances in MC@NLO-type simulations. Applied to single top, valid in general. It has been implemented in the code for a while

- In 1604.03017 we have FxFx-ed $gg \to H^0$ production including top and bottom mass effects (and 2-loop virtuals for 0 jets). This is (or will become) phenomenologically relevant




## $W-b$ jet mass (1603.01178)

- Broadening of spectrum
- on-shell+MS not bad, if $\mathcal{O}(10\%)$ effects are tolerated
- Off-shell effects are important; decently described by MS
- Might have a significant impact on top-mass extraction




Higgs $p_T$ (1604.03017)

- $b$-mass effects only at low $p_T$
- At large $p_T$, multi-jet merging and mass effects pull in different directions
- Excellent merging-scale stability

- The resonance treatment is ready to go (at least for PY8). Lots of CPU will be required for involved processes

- $H + j$'s relied on a private patch for v2.4.X. This is not necessary any longer (thanks to the reweighting package). However, minor adjustements are necessary for v2.5.X.

  We're happy to implement them if there is a real commitment to generate events