Studies on the improvement of the matching uncertainty definition in top-quark processes simulated with Powheg+Pythia 8

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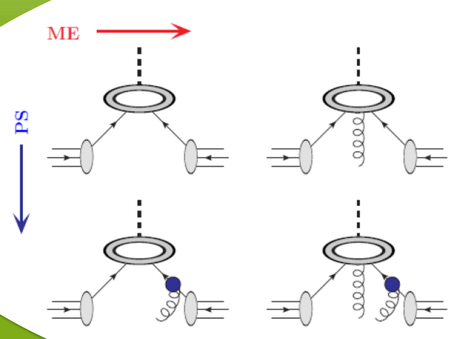
ATL-PHYS-PUB-2023-029

TOP 2023

Introduction

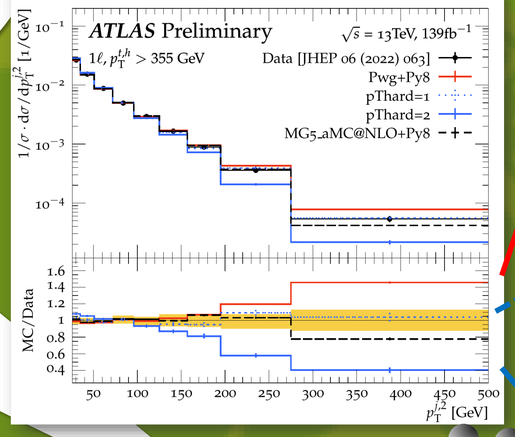
Double counting between real emissions in the matrix element (ME) calculation - Powheg - and the parton shower (PS) - Pythia 8 - is avoided by a so-called vetoed shower. Here Pythia 8 generates emissions in the full phase-space but vetoes the emissions in regions of the phase space already covered by Powheg. The order of the emissions in the event evolution is based on a variable related to the transverse momentum (p_T) called "hardness" [1]. A difference in the definition leads to double counting or regions in the phase space not modelled.

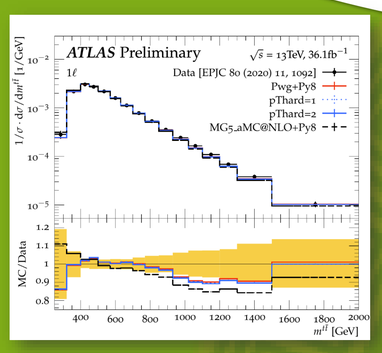


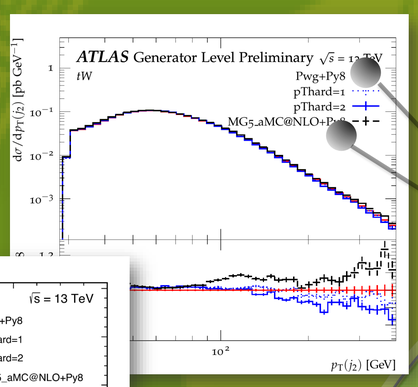
pThard = 0
The Powheg hardness value

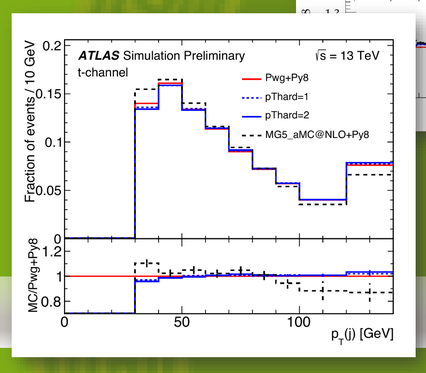
pThard = 1
the p_T of the Powheg emission

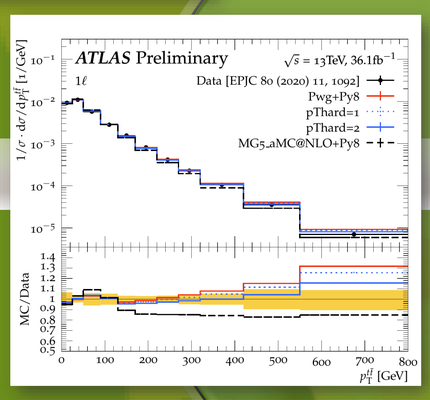
pThard = 2
the minimal p_T among all the final-state partons

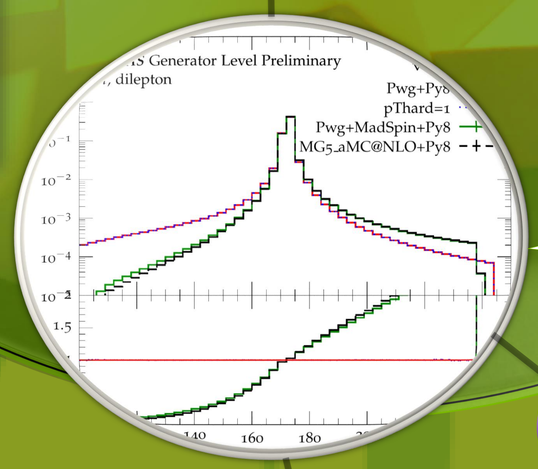






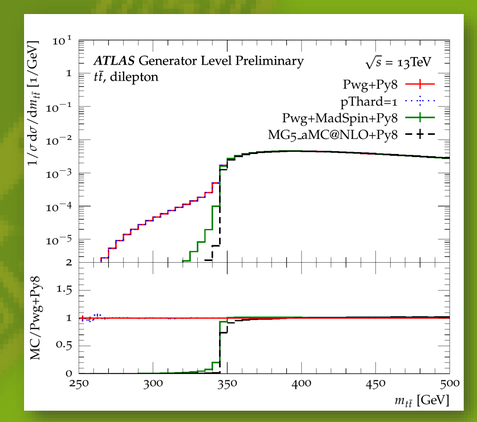






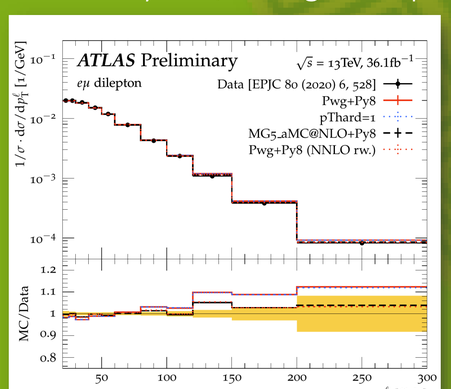
Top quark lineshape

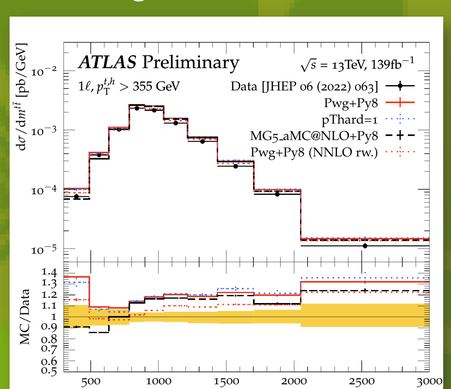
Decay of the top-quark is based on the narrow width approximation with a smearing of a Breit-Wigner followed by momentum reshuffling. Two different ways of doing this are implemented in PowhegBox and MadSpin.



Top-quark p_T mis-modelling

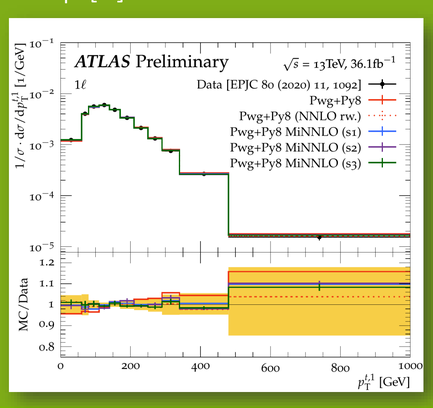
Several measurements from ATLAS and CMS have observed a mis-modelling of the top-quark pT. The mis-modelling appears to be related to the absence of higher-order corrections that would soften the top-quark pT spectrum. A reweighted (using weights from a NNLO calculation) nominal sample can be used to access a system uncertainty and/or to get the prediction in agreement with the data

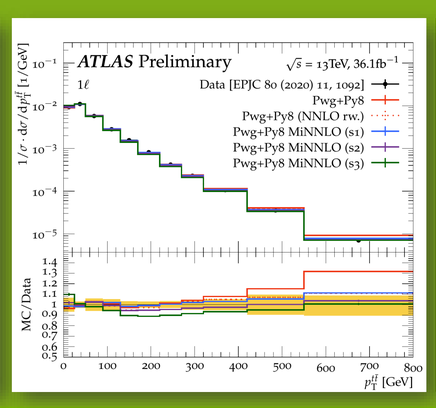


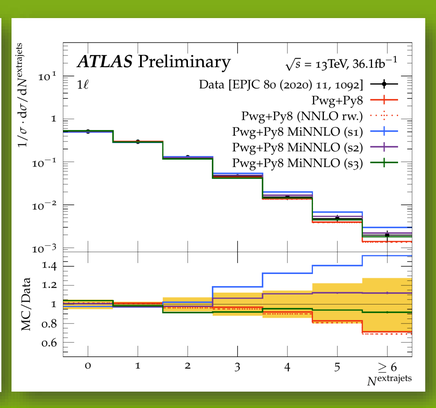


Higher order predictions including parton shower

The deficit of missing higher order corrections can be overcome by using a consistent NNLO+PS model – available in the PowhegBox. However the matching of this MiNNLOPS setup [2] is not trivial and needs further studies







Recipe

Powheg vs. MG5_aMC@NLO

pThard=0 vs. pThard=1
Powheg vs. MadSpin

NNLO top p_T reweighting
(to be exchanged with MiNNLOPS soon)

References:
[1] SciPost Phys. 12 (2022)
[2] JHEP 04 (2022) 079

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