IL NUOVO CIMENTO **39 C** (2016) 218
DOI 10.1393/ncc/i2016-16218-9

Colloquia: IFAE 2015

A tune of the PYTHIA8 generator to ATLAS measurements of top pair production at $\sqrt{s} = 7$ TeV

S. Amoroso

Physikalisches Institut Universitat Freiburg - Freiburg, Germany

received 7 January 2016

Summary. — We present results of a tune of the initial- and final-state radiation parameters of the Pythia8 Monte Carlo generator to various measurements of $t\bar{t}$ production performed by the ATLAS experiment at $\sqrt{s} = 7$ TeV. The tune is further applied to the next-to-leading-order generators MadGraph5_aMC@NLO and Powheg, and additional parameters of these generators are tuned to the $t\bar{t}$ data.

At the LHC collider, for the first time, $t\bar{t}$ processes can be measured with enough accuracy to be used in Monte Carlo (MC) tunes. Aim of this work is to study the sensitivity of these measurements to the initial- (ISR) and final-state radiation (FSR) parameters in the Pythia8 generator. The tunes are performed with the Professor program and with Rivet for the implementation of the measurements. For the first time in the context of MC tuning the correlations in the uncertainties among bins of the same observable and of different observables have been considered.

The Monash tune is used as baseline tune and four parameters are considered for the optimization. These are the value of $\alpha_S(m_Z)$ in the initial- and final-state showers, a fudge factor for the damping of the ISR radiation ($p_{T,damp}^{ISR}$) and the infrared cut-off of the final state shower ($p_{T,min}^{FSR}$). The ISR parameters are tuned to a measurement of differential $t\bar{t}$ cross sections as function of jet multiplicity and transverse momentum and a measurement of gap fraction as function of Q_0. The tuned parameters are found to be in agreement among the two different analyses and with the AZ tune to Z p_T data. A measurement of jet shapes in $t\bar{t}$ events is used to tune the FSR parameters. The result show tension between the light- and b-jet shapes, the low value of $\alpha_s^{FSR}(m_Z)$ obtained for the b-jet shapes being incompatible with LEP data. Removing the b-jet shapes from the tune helps in obtaining a χ^2/ndf close to one and gives a value of $\alpha_s^{FSR}(m_Z)$ of 0.137, compatible with LEP determinations. The resulting high value of $p_{T,min}^{FSR}$, of about 1 GeV, leaves however an undesiderable gap between the infrared cut-off of the shower and the starting scale of hadronization. A combined tune of all four parameters (ATTBAR) is finally performed [1]. The resulting values of the parameters, as shown in table I, are in agreement with the independent tunes. Including correlations allows to reduce

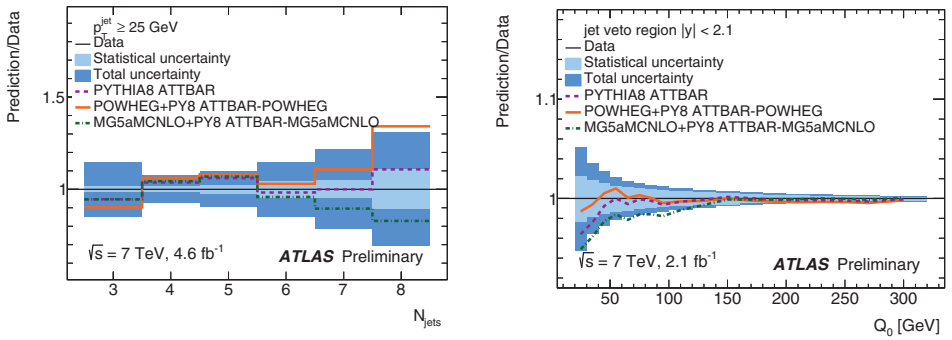

Fig. 1. – Predictions of Pythia8 (dashed magenta line), MadGraph5_aMC@NLO+Pythia8 (green dashed and dotted line), and Powheg+Pythia8 (orange continuous line) with the ATTBAR tunes compared to the measured differential $t\bar{t}$ cross sections as functions of jet multiplicity for jets with $p_T^{\text{jet}} \geq 40\,\text{GeV}$ and gap fraction as a function of Q_0.

Table I. – *The optimal parameters and their uncertainties as determined in the ATTBAR tune.*

Parameter	ATTBAR
$\alpha_s^{ISR}(m_Z)$	0.121 ± 0.004
$p_{T,damp}^{ISR}$	1.18 ± 0.08
$\alpha_s^{FSR}(m_Z)$	0.137 ± 0.003
$p_{T,min}^{FSR}$ $[GeV]$	1.26 ± 0.17
$\chi^2_{\text{min}}/\text{dof}$	92/85

the uncertainties in the parameters by up to 50% and to obtain a χ^2/dof close to one. The variation in the ISR and FSR parameters induces a change in the underlying event activity. Assuming universality between $t\bar{t}$ and Z boson production, the MPI cut-off has been retuned to Z events and a value of 2.28 GeV is obtained.

The ATTBAR tune is finally applied to NLO+PS generators and two additional parameters related to the scale of the process are tuned to data. In Powheg the damping factor for the singular part of the real radiation (hdamp) is tuned, obtaining a preferred value of $1.8 \cdot m_t$. In MadGraph5_aMC@NLO the considered parameters are frac_upp and frac_low, which determine the minimum and maximum fractions of the reference scale used as an upper limit for the MC subtraction term. The best agreement with the data is found by fixing both parameters to the same common value f and using the local-recoil strategy, for which a value of 0.54 is obtained in the tune. The predictions of the tunes to the three generators are shown in fig. 1.

REFERENCES

[1] ATLAS Collaboration, *ATL-PHYS-PUB-2015-007*, (A study of the sensitivity to the Pythia8 parton shower parameters of $t\bar{t}$ production measurements in pp collisions at $\sqrt{s} = 7\,\text{TeV}$ with the ATLAS experiment at the LHC).