New ATLAS Event Generator Tunes to 2010 pp Collision Data at 7 TeV Centre-of-Mass Energy

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Using data recorded during 2010, the ATLAS experiment has been able to measure many QCD observables at previously inaccessible energy scales, by using the 7 TeV centre-of-mass energy proton-proton collisions provided by the LHC. These measurements have been used to produce new tunes of the general-purpose Monte Carlo (MC) generators PYTHIA 6 and HERWIG/JIMMY, to provide improved predictions for a wide range of QCD obervables up to jets of $p_T \sim 2$ TeV [1].

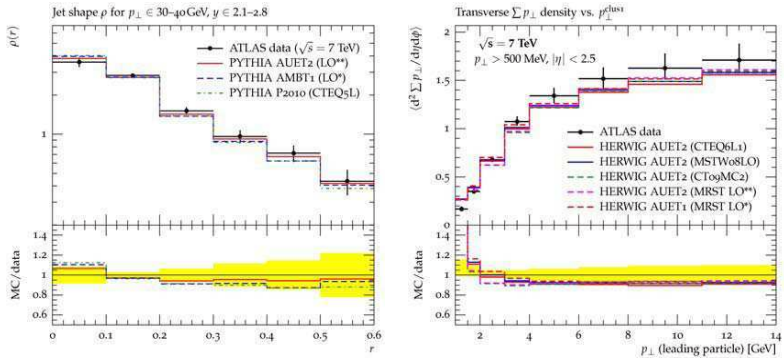
A comprehensive tuning of PYTHIA 6, using the p_T-ordered parton shower algorithm, was performed as described in Ref. [1], using measurements from e^+e^-, Tevatron and ATLAS data. Aspects of the procedure where ATLAS 7 TeV data plays an important role will be focused on here.

The tuning of initial state shower parameters and primordial k_T was based on the strategy used for the Perugia 2010 tune. Figure 1(a) shows jet shape variables in data and MC for a 30-40 GeV jet p_T slice. As a result of this tuning, these variables in MC, which had shown discrepancies from data of up to 15% using the previous ABMT1 tune, now agree with data at the level of approximately 5%.

For the tuning of Multiple Partonic Interaction (MPI) parameters, minimum bias and underlying event datasets were used as inputs. A single MPI tune was unable to satisfactorily describe both ATLAS minimum bias and underlying event data, and so two tunes were produced; AMBT2 and AUET2. Using the dedicated AUET2 tune for underlying event simulation provides a definitive improvement over AMBT1. While for minimum bias simulation, the AMBT2 tune shows improvements over AMBT1 in several observables, including the statistically dominant part of the charged multiplicity distribution, a deterioration in the jet p_T spectrum description results in this tune being appropriate as an alternative for systematics studies rather than a definitive replacement.

As was done previously for the AUET1 tune [2], the parameters of JIMMY (an add-on generator to HERWIG, used to model MPI) were also tuned to ATLAS underlying event data. An energy evolution for the MPI cut-off energy was required to be added to JIMMY, to allow simultaneous tuning to data at 900 GeV and 7 TeV. Tunes were performed for ten different leading order, modified leading order, and next-to

leading order parton density functions, to investigate their effects in a leading order matrix element generator. The multiple tunings of MPI parameters within JIMMY demonstrate the ability to 'industrialise' the MC tuning process. Similar levels of agreement with data were found to be attainable regardless of the PDF that was used, as seen in Figure 1(b). For the future, HERWIG++ will be preferred to HERWIG/JIMMY, due to its more complex parton shower model which includes features such as colour reconnection.



(a) Jet shape in data and PYTHIA AUET2

(b) Transverse Σp_T in data and HERWIG AUET2 tuned to several leading order PDFs

Figure 1: Comparisons between ATLAS 7 TeV data and new MC tunes.

Subsequently to the work described here, AMBT2B and AUET2B Pythia 6 tunes have also been produced [3], which address some of the remaining issues (such as the aforementioned AMBT2 jet p_T spectrum discrepancies). However, separate tunes are still required to describe minimum bias and underlying event data.

References

[1] The ATLAS Collaboration, *New ATLAS event generator tunes to 2010 data*, ATL-PHYS-PUB-2011-008.

[2] The ATLAS Collaboration, *First tuning of HERWIG/JIMMY to ATLAS data*, ATL-PHYS-PUB-2010-014.

[3] The ATLAS Collaboration, *ATLAS tunes of Pythia 6 and Pythia 8 for MC11*, ATL-PHYS-PUB-2011-009.