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New tunes of PYTHIA8 to the Minimum Bias data at 13TeV using different PDF sets

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PYTHIA8 simulates a number of physics aspects by implementing several models along with theory; these models have many free parameters that need to be tweaked for the best description of data. In this study, we use PYTHIA 8.2 for the simulation of Multiparton Interactions using different PDF sets from LAHPDF6. Altogether five parameters were selected for the final tune depending on their sensitivity to the selected observables at 13TeV published by ATLAS Collaboration. Simulated experimental analysis data is obtained using the Rivet analysis toolkit. These tunes are substantial improvements on existing standard choices and describe the selected data reasonably well. Tuning results are also compared with the default tunes in PYTHIA 8.

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1. Introduction

Since all the Physics aspects involved in high energy hadronic collisions cannot be derived from first principles, simulation software like PYTHIA [1], employ different physics models to simulate these collisions. These Physics models contain many parameters that represent uncertainty in our understanding of nature. Among others Multiparton interactions and hadronization are the most sensitive processes, both involve nonperturbative QCD physics.
These parameters are termed as free parameters and need to be tweaked to describe the experimental data [8]. Technically, PYTHIA parameters can be varied independently of each other, but the physical requirement of a sensible description of a set of data leads to correlations and anticorrelations between models and their the parameters. Hence model parameters should not be varied one by one but simultaneously for a group of them. In this study, we focussed on Multiparton interaction Model including color reconnection treatment and impact parameter dependence models. Altogether four parameters are varied: three parameters of the Multiple Parton Interaction (MPI) model and one Colour Reconnection Model parameter for LO and NLO PDFs using Minimum Bias published data at 13 TeV from the ATLAS experiment. For the tuning, we have made use of Professor Tuning Software [3]. All the data Monte Carlo comparison plots are created using the Rivet Analysis tool [2].

2. Multiple Parton Interactions Modelling

A detailed description of multiparton interactions modeling in PYTHIA 8, Monte Carlo event generator [10] is provided by [11], recent developments can be found in [4]. Protons can be averred as a collection of gluons and quarks, called partons. It is then possible to have multiple parton hard scatterings meaning events in which two or more distinct hard partonic interactions occur simultaneously in a single hadronic collision. One of the key parameters in a complete PYTHIA tune is pT0Ref. Its value is intimately tied to a number of other choices, such as that of color flow description, so it is difficult to give a specific meaning to pT0Ref, because of its importance in describing MPI model and sensitivity to the selected observables included in the tuning. The other two parameters are related to impact-parameter dependence. The choice of impact-parameter dependence is regulated by several parameters and among four different options provided by PYTHIA 8 we have used a double Gaussian matter distribution, with the two free parameters coreRadius and coreFraction (MultipartonInteractions: coreRadius and MultipartonInteractions: coreFraction). This selection is based on other independent studies which show double Gaussian matter distribution provide better results as compared to other options. One parameter ColourReconnection:range is related to the color reconnection process where an MPI-based scheme is selected. The higher this number is, the more reconnections can occur [9].

3. Results

Tuned values of four parameters considered for simultaneous variation in this paper are listed in Table 2 for three different PDFs shown in Table 1 ; Leading Order, Mod-Leading Order, and Next to Leading Order. Distributions used in this study are from diffraction-limited phase spaces [5].

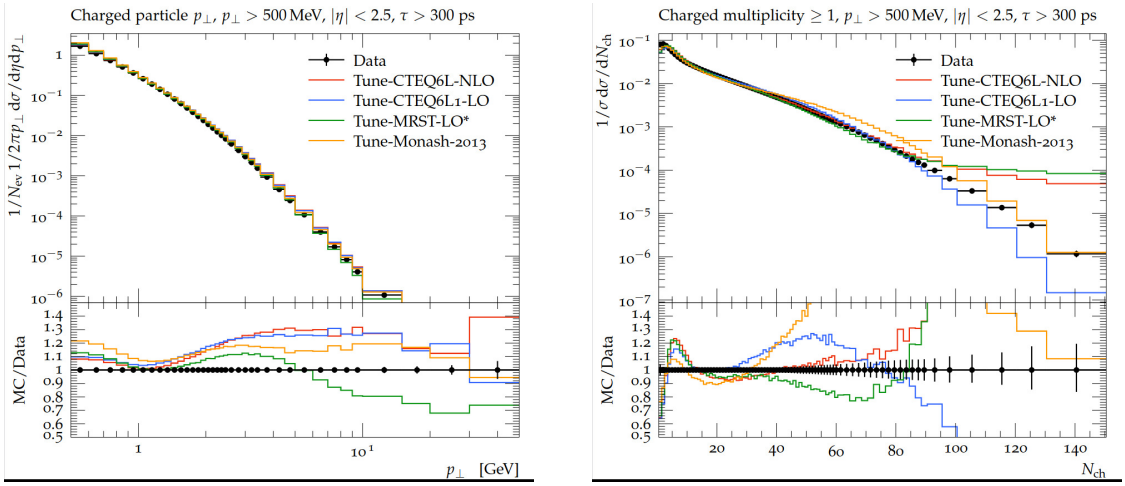

Figure 1: Data / MC comparison plots: charged Pt and charged multiplicity distributions at 13 TeV

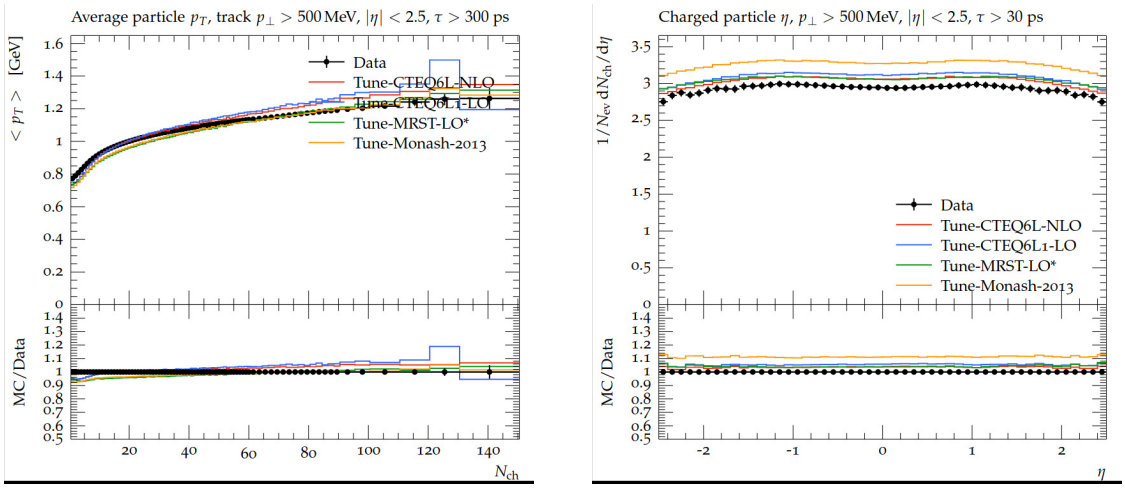

Figure 2: Data / MC comparison plots: average pt Vs Multiplicity and eta distributions at 13 TeV

Comparison plots of three new tunes and default tune to the ATLAS charged multiplicity Nch, pt distributions (Figure.1), average Pt vs charged multiplicity Nch and eta distributions (Figure.2), and charged pt and eta distributions are presented. It is shown that all tunes including Monash 13 are unable to describe Nch completely. All tunes describe multiplicity distribution for this phase space in the same way but the description is rather bad. Eta distribution is described in a better way as compared to the default tune which shows little higher activity than required by data, this effect can also be seen in the multiplicity distribution. In Figure 1 pt description is better for all the new tunes with a hard-tail than the data but this discrepancy is not very significant. Average Pt Vs Nch is very sensitive observable and described equally well by all the selected tunes. This distribution is very sensitive to the selected PDF types but is strongly correlated to the MultipartonInteractions:pT0Ref parameter.

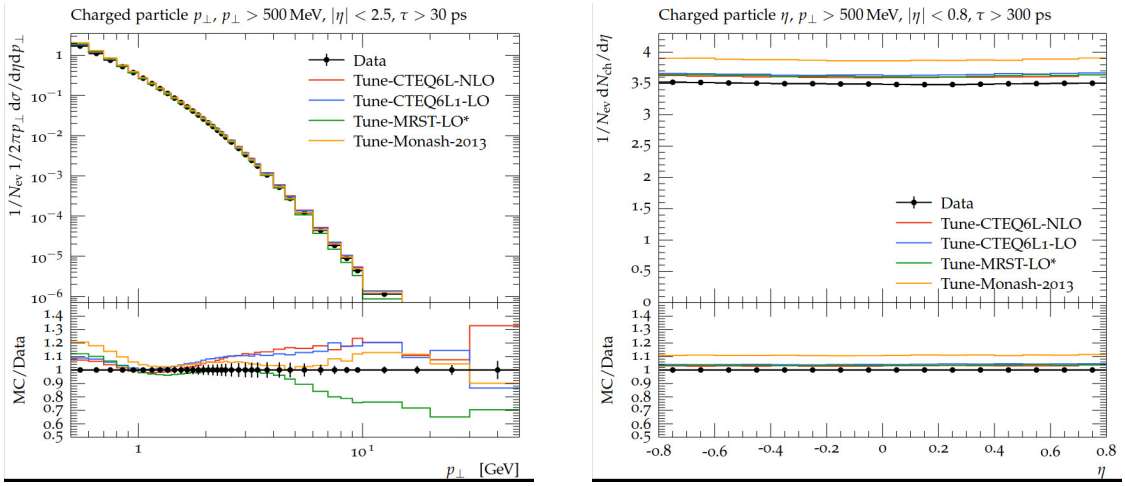

Figure 3: Data / MC comparison plots: charged pt and eta distributions at 13 TeV

PDF Type	**PDF Set**
Leading Order (LO)	CTEQ6L1
Modified Leading Order	MRST(LO*)
Next-to-Leading Order	CTEQ6L

Table 1: List of PDF sets

Parameter	**CTEQ6L1**	**MRSTLO***	**CTEQ6L**
MultipartonInteractions:coreFraction	0.626	0.793	0.245
MultipartonInteractions:coreRadius	0.920	0.107	0.106
MultipartonInteractions:pT0Ref	2.632	1.922	2.788
ColourReconnection:range	2.440	2.037	1.741

Table 2: List od tuned parameters

4. Conclusion

New tunes of PYTHIA8 to Minimum Bias data at 13TeV using 3 PDFs including Leading Order, Mod-Leading Order, and Next to Leading Order are presented. New tunes are also compared with the default tunes in PYTHIA8, i.e. Monash-2013 [6]. We show that different PDFs describe data differently, though overall results do not vary greatly. To increase the agreement between Monte Carlo and experimental data, more free parameters of the selected models employed in PYTHIA should be included in the tunings. Also more detailed model/parameter study [8] should be performed before final tunes to check their sensitivity to the selected data.

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