Note on the CMS multiplicity distributions

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Abstract

The CMS data on the multiplicity distributions are compared with the results from the 8.142 version of the PYTHIA MC event generator with the default tuning and realistic impact parameter profile. The agreement is reasonable. However, it seems to be difficult to improve further this agreement by tuning the parameters determining the multiple parton interactions.

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1 Introduction

In a recent paper [1] we have discussed the data on the multiplicity distributions at the LHC energies. We have confirmed our earlier observation [2] that the observed fast increase of the average multiplicity with energy [3], [4], [5] follows from the standard parametrizations used in the PYTHIA 8 event generator [6], [7]. The average multiplicity as well as the scaled moments of the distribution in the wide energy range are qualitatively compatible with these parametrizations.

In this note we discuss in more detail the CMS data [5] on the multiplicity distributions at three energies and two pseudorapidity intervals. Introducing a more realistic impact parameter profile we find a reasonable quantitative agreement of the data with PYTHIA 8.142 for the default values of its parameters. We consider also some further tuning.

2 Data and model results

The CMS data contain 132, 12 and 442 thousand events at 0.9, 2.36 and 7 TeV, respectively. The trigger is selected to remove the bulk of single diffractive events and the additional corrections are made to obtain a possibly pure non-single-diffractive (NSD) sample. The results for the average multiplicity $\bar{\pi}$ and the three lowest scaled moments

$$c_q = \frac{n^q}{n}$$

for $q = 2, 3, 4$ and for two choices of the central pseudorapidity bin widths: $\Delta\eta < 1$ and $\Delta\eta < 2.8$ are shown in Figs. 1-4.

![Figure 1](image-url)

Figure 1: The average multiplicity from the CMS data at 0.9, 2.36 and 7 TeV (black dots with error bars) and from PYTHIA 8.142 (open squares) for the pseudorapidity bin width of 2.8 are shown.

The PYTHIA 8.142 is run for NSD events with the default values of parameters and one modification: the impact parameter profile is not a single Gaussian, as in the default version, but a (more realistic) combination of two Gaussians, as used in the earlier versions of PYTHIA 8. The results are also shown in Figs. 1-4. We repeat that the PYTHIA
parameters are not fitted to these data but are taken from the default version. Thus this agreement may be regarded as a good one.

In the previous paper we have compared two different tunings of PYTHIA 8.142: the default in the 8.135 version. They were bracketing the experimental results and the differences were growing rather fast with energy (for the energies below LHC the differences were negligible). This was due to the different energy dependence of the lower cut for the transfer momenta used to calculate the multiple parton interactions. Now we have found that the default version, modified only in the shape of the b-profile, agrees quite well with the data and no further tuning seems necessary.
3 Conclusions and outlook

We have found a reasonable agreement between the predictions of PYTHIA 8.142 and the CMS data. However, the detailed comparison of the model and data shows that the average multiplicity is slightly underestimated, but the scaled moments are (also slightly) overestimated. The energy dependence is similarly slightly too weak for the average but too fast for the scaled moments.

We have checked that tuning the parameters determining the multiple interactions we increase or decrease simultaneously both the average and the scaled moments. Thus to improve further the agreement with data it would be probably necessary to tune the parameters different from that ones we considered here.

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