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SELECTING THE DIFFRACTIVE EVENTS AT THE LHC ENERGIES

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The PYTHIA 8 generator is used to estimate the percentage of the non-diffractive and diffractive events at the LHC energies. It is shown that a simple condition of the absence of charged hadrons in the central pseudorapidity region is sufficient to remove almost all non-diffractive events. This opens the way to investigate diffraction without waiting for the future specialized detectors.

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1. Introduction

The first data on the multiplicity of hadrons produced at the LHC energies were extensively analyzed and compared with lower energy data. An obvious difficulty in such comparisons is the distinction between the non-diffractive (ND), single diffractive (SD) and double diffractive (DD) events, for which all models predict different energy dependence. In the data it is rather difficult to distinguish unambiguously these classes of events. Thus the simplest way to proceed is to define by some kinematic conditions the sample of events to be compared with models, and then to impose the same conditions on the model predictions.

An example of such a condition was introduced by the ALICE Collaboration, where the multiplicities in the pseudorapidity range from -1 to 1 were measured for the inelastic events having at least one charged hadron in this range [1]. Such a sample is customarily denoted as INEL > 0. It was shown [2] that the average multiplicities for the INEL > 0 sample are successfully described by the PYTHIA 8 generator [3, 4, 5], if some parameters are properly tuned. However, it was also noticed that this sample of events contains significant contributions from all the classes of events mentioned above (ND, SD and DD). In the samples generated by PYTHIA 8 the proportion of these contributions (ND:SD:DD) depends on the used version of MC and changes slowly with energy.

This fact was regarded as disadvantageous, since a simple physical interpretation of the data seems possible for the ND sample, and not for the unspecified mixture of the ND, SD and DD events. However, one could note that the condition of at least one charged hadron in the central pseudorapidity bin leaves the ND contribution almost intact, whereas a large percentage of the SD and DD events is then removed.

We use this observation to propose a simple way to construct a diffractive sample of events from the LHC data without using specialized "diffractive" detectors, which are mostly in the construction phase. The results from the PYTHIA 8 generator suggest that by requiring **no** charged hadrons in the central pseudorapidity bin we remove very effectively the ND contribution.

In the next section we specify the versions of MC generators used and the generating conditions. Then we present the results. We complete the note with some conclusions and outlook.

2. Procedures and results

We are using two recent versions of PYTHIA: 8.135 and 8.145. For the latter we check the influence of the values of some tuning parameters. Specifically, we compare two choices of the parameter values for the description of multiple scattering effects. The parameters define the regularization of the (divergent) QCD cross section by introduction of the factor

$$F(p_{\rm T}) = \frac{p_{\rm T}^4}{\left(p_{\rm T0}^2 + p_{\rm T}^2\right)^2}.$$

With an energy independent value of $p_{\rm T0}$ the average multiplicity would increase too fast with CM energy E. Thus a mild power-like dependence is assumed:

$$p_{\rm T0} = p_{\rm T0}^{\rm ref} \left(\frac{E}{E^{\rm ref}}\right)^{\alpha}.$$

The default values of $E^{\rm ref}$ and α are 1800 GeV and 0.24, respectively. The modified values, for which the average multiplicities are better described, are 1000 GeV and 0.30. In both cases the $p_{\rm T0}^{\rm ref}$ value is 0.2 GeV/c. We generate 100k events for each energy, each class of events and each version of the MC generator. Then we calculate the fraction of events which pass the condition of no charged hadrons in the central pseudorapidity bin. The bins of one- and two units width are used.

The results are summarized in Table I. For transparency, the results for various versions of MC generators are not shown separately, but the central value and the spread (in brackets) of percentages is given. This spread should be a fair estimate of the model uncertainties.

TABLE I

The percentages of ND, SD and DD events for various samples of data at three LHC energies from the PYTHIA 8 generator.

E [TeV]	Class of events	ND	SD	DD
0.9	Inclusive	65.5(0.3)	22.3(0.1)	12.2(0.1)
0.9	$N = 0$ in $\Delta\eta = 1$	21.5(4.5)	50.7(2.2)	28.0(1.5)
0.9	$N = 0$ in $\Delta\eta = 2$	5.0(1.8)	62.1(1.0)	33.0(0.8)
2.0	Inclusive	66.0(0.2)	21.2(0.2)	12.7(0.2)
2.0	$N = 0$ in $\Delta\eta = 1$	19.8(3.6)	50.2(2.6)	29.3(1.8)
2.0	$N = 0$ in $\Delta\eta = 2$	4.3(1.6)	60.8(1.3)	35.4(0.8)
7.0	Inclusive	67.5(0.2)	19.4(0.3)	13.0(0.2)
7.0	$N = 0$ in $\Delta\eta = 1$	19.1(5.2)	48.5(3.7)	32.2(1.6)
7.0	$N = 0$ in $\Delta\eta = 2$	3.3(1.4)	57.3(3.6)	39.5(2.3)

We see that already the condition of no hadrons in the central pseudorapidity bin of the length of one unit removes the great part of ND events. By requiring no hadrons in central two units of η we get an almost pure diffractive sample: less than one event in 20 is non-diffractive. Obviously, some diffractive events are also rejected, but the loss is usually less than a half of the sample.

3. Conclusions and outlook

We have checked that in the PYTHIA 8 generator a simple condition to accept only the events without charged hadrons in the central two units of pseudorapidity removes almost all the non-diffractive events. Thus an almost pure diffractive sample of events may be easily selected.

Obviously, this conclusion may not be valid for other generators. In particular, if a model predicts a long tail of the rapidity gap distribution in non-diffractive sample, the results may be quite different. However, it seems that the PYTHIA 8 describes various LHC data well enough to justify the confidence that our results apply to the data.

The possibility to extract the diffractive contribution from the existing data without waiting for the dedicated diffractive experiments seems quite attractive. An example of a possible use of such procedure may be the investigation of the charge asymmetry for $W^{+/-}$ boson production. It is well known that the excess of valence u quarks in protons results in an excess of positive leptons from the W decays [6, 7]. Such an excess should not occur for so-called double Pomeron exchange ("central diffraction"), since the u/d quarks (antiquarks) are perfectly balanced in the Pomeron. For the single Pomeron exchange, *i.e.* the SD and DD samples, the asymmetry should be about half of that observed for the ND events. However, there are models in which soft quark/gluon exchange in the final state change these expectations. Thus testing such predictions seems worthwhile [8]. With our condition one may do it easily. Other applications are certainly possible.

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REFERENCES

[1] K. Aamodt *et al.* [ALICE Coll.], *Eur. Phys. J.* **C68**, 345 (2010).

[2] K. Fiałkowski, R. Wit, *Eur. Phys. J.* **C70**, 1 (2010).

[3] T. Sjöstrand, S. Mrenna, P. Skands, *J. High Energy Phys.* **05**, 026 (2006).

[4] T. Sjöstrand, S. Mrenna, P. Skands, *Comput. Phys. Com.* **178**, 852 (2008) [arXiv:0710.3820 [hep-ph]].

[5] http://home.thep.lu.se/ torbjorn/Pythia.html

[6] G. Aad *et al.* [ATLAS Coll.], *Phys. Lett.* **B701**, 31 (2011).

[7] S. Chatrchyan *et al.* [CMS Coll.], *J. High Energy Phys.* **1104**, 050 (2011).

[8] K. Golec-Biernat, C. Royon, L. Schoeffel, R. Staszewski, *Phys. Rev.* **D84**, 114006 (2011).