PROCEEDINGS OF SCIENCE

Comparison of the triggers of the ATLAS, ALICE and CMS experiments and the trigger of the UA1 experiment. Analysis of proton-proton and proton-antiproton interactions on basis of the MC event generator Pythia

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The triggers of the ATLAS, ALICE and CMS experiments for proton-proton collisions and the trigger of the UA1 experiment for proton-antiproton collisions are considered. It is shown that uncertainties which arise from different procedures of event selection are not sufficient to explain the difference of about 20–30% in inclusive spectra between the LHC experiments and the UA1 experiment. The dissimilarity in proton-proton and proton-antiproton interactions in simulation by the MC event generator Pythia is also discussed.

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1. Introduction

The Collaborations CMS [1], ATLAS [2] and ALICE [3] have published inclusive charged particle transverse momentum distributions in pp interaction at center-of-mass energy $\sqrt{s} = 900$ GeV

$$\frac{1}{2\pi p_T}\frac{d^2 n_{ch}}{d\eta dp_T} \tag{1}$$

where p_T is transverse momentum of observed particle, η – pseudorapidity. The Collaborations ATLAS and ALICE have compared their results with results of the UA1 [4] Collaboration in proton-antiproton interaction at the same energy. The CMS Collaboration have not compared its results with the results of UA1, the comparison was made by the authors of this report, Fig. 1.

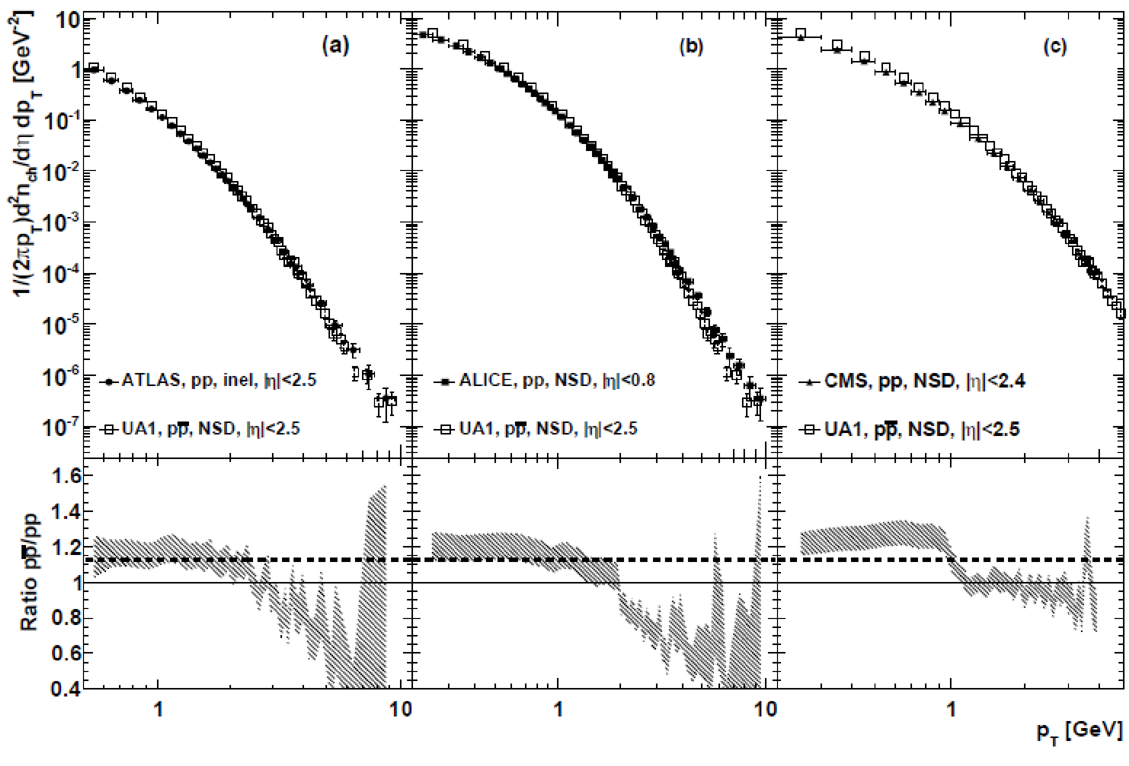

Figure 1: The ratios of invariant inclusive cross sections of the UA1 [4] to ATLAS [2] (a), ALICE [3] (b) and CMC [1] (c) at $\sqrt{s} = 900$ GeV. The shaded areas indicate the errors of the ratios. The dashed line shows the value of ratio $R = 1.12$, our prediction from the LCNM [5]. The solid line at 1 is shown to guide the eye

The ratio of proton-proton cross section to proton-antiproton R is about $R \approx 1.2$ for the ATLAS and ALICE data and $R \approx 1.3$ for the CMS data in range of transverse moments up to

$1 \div 2$ GeV/c. In the present report we will discuss if it is possible to explain this difference by different trigger conditions in the UA1, UA5, ATLAS, ALICE and CMS experiments.

2.The trigger requirements

The trigger requirements of considered experiments are given in Fig. 2.

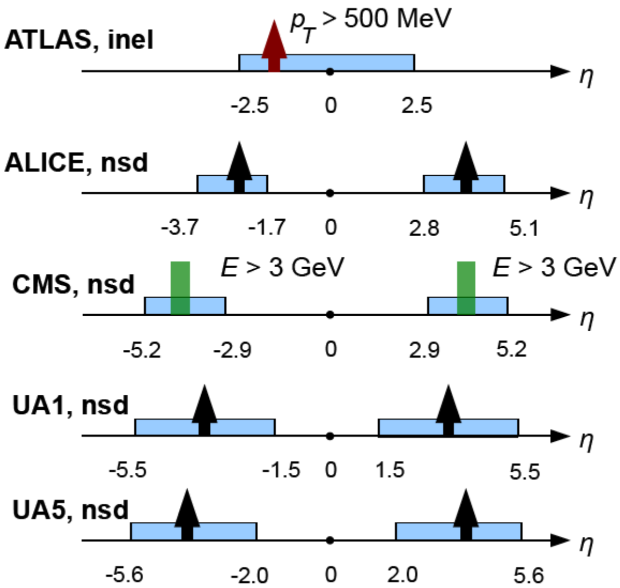

Figure 2: The schematic presentation of trigger requirements of different experimental setups

The ATLAS Collaboration [2] gave data which were collected when there was at least one particle with transverse momentum $p_T > 500$ MeV in pseudorapidity range $|\eta| < 2.5$ in an event. The ATLAS Collaboration normalizes data by inelastic cross section σ^{inel} while all the other collaborations normalize their data by non single diffractive cross section σ^{nsd}. They achieve this goal by using the "two-arm trigger" logic which implies two ranges of pseudorapidity divided by some gap. If there are two particles in an event in each of these ranges then this event is believed to be a non single diffractive event. The ALICE Collaboration [3] requires two coincidence hits in pseudorapidity ranges $-3.7 < \eta < -1.7$ and $2.8 < \eta < 5.1$. The CMS Collaboration [1] requires two coincidence of at least one calorimeter tower with more than 3 GeV total energy on each of the positive and negative sides in ranges $2.9 < |\eta| < 5.2$. The UA1 [4] and UA5 [6] Collaborations both had similar requirements of two coincidence hits in pseudorapidity ranges $1.5 < |\eta| < 5.5$ (UA1) and $2.0 < |\eta| < 5.6$ (UA5).

Of course the "two-arm trigger" logic needs some model-dependent corrections and they are usually done with help of Monte Carlo simulations, in particular Pythia simulations. Here we will not consider model-dependent corrections, but we will try to investigate the net effect of different trigger setups on one and the same sample of generated events. We will not discuss the problems connected with a detector acceptance and its efficiency since these subtle issues are open only to collaborations members.

3.Results

The ATLAS and ALUCE Collaborations have stated that the 20% difference between their data and the UA1 proton-antiproton data is “expected from the double-arm scintillator trigger requirement used to collect the UA1 data, which rejected events with low charged-particle multiplicities” [2, 3]. Unfortunately, they have not presented the quantitative estimation of this trigger effect.

We have generated a sample of one million inelastic proton-proton events using Pythia-6.4.21 default tune [7] and also tunes Perugia 0 [8] and D6T [9]. Each event was examined by the trigger requirements given in Fig. 2. The fractions of diffractive events which passed the selection criteria are given in the Table 1.

Table 1: Fractions of diffractive events in the same sample of generated proton-proton events after the different trigger requirements

	Pythia, default	Pythia, Perugia 0	Pythia, D6T
Fraction of single-diffractive events (SD)			
ATLAS trigger	9.5 %	8.0 %	9.5 %
ALICE trigger	5.8 %	5.4 %	5.8 %
CMS trigger	4.3 %	4.0 %	4.2 %
UA1 trigger	9.1 %	9.3 %	9.1 %
UA5 trigger	6.3 %	5.9 %	6.3 %
Fraction of double-diffractive events (DD)			
ATLAS trigger	5.1 %	4.3 %	5.0 %
ALICE trigger	4.4 %	4.1 %	4.4 %
CMS trigger	4.7 %	4.2 %	4.6 %
UA1 trigger	9.5 %	9.4 %	9.4 %
UA5 trigger	6.3 %	5.8 %	6.2 %

If data contains large fraction of diffractive events it tends to be lower than non diffractive data. So the effect from different trigger requirements is opposite to the observed – the UA1 trigger lowers the data as shown in Fig. 3, the ratio is lower than 1.

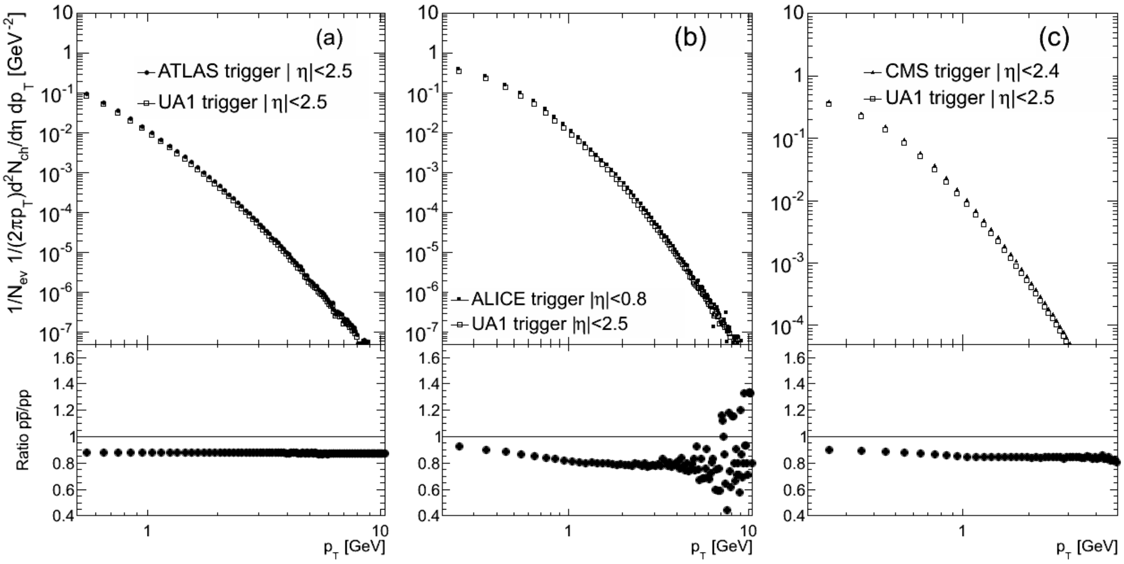

Figure 3: The ratios of invariant inclusive cross sections of the UA1 to ATLAS (a), ALICE (b) and CMC (c) at $\sqrt{s} = 900$ GeV as obtained from one and the same proton-proton event sample but with different trigger requirements. The solid line at 1 is shown to guide the eye

In the UA1 Collaboration paper [4] it is said that "Events are retained for the analysis if they fulfill requirements on the timing of the trigger hodoscope, on the vertex reconstruction by the CD and on the total energy deposited in the calorimeter. These cuts reject background due to beam-gas interactions and halo particles that trigger the detector, and have been defined after a careful inspection of a number of events, taken in different beam conditions, with an interactive graphic display. The fraction of rejected triggers was 25% at 0.2 TeV and 12% at 0.9 TeV."

In the modern experiments the fraction of rejected triggers is very small. So in order to reproduce this feature of the UA1 data we can randomly reject events with low multiplicities $N_{ch} \leq 16$ from the sample of generated events that passed the UA1 trigger requirement. The result is shown in the Fig. 4. One can see that the combined effect of different trigger requirements plus the effect of triggers rejection at UA1 gives ratio close to 1, so these two effects actually cancel each other. So the observed opposite effect in the actual, not simulated data, can be attributed to the difference in reactions – proton-antiproton in case of the UA1 and proton-proton in case of the LHC experiments. It should be note that the ALICE trigger still gives lower ratio because of different pseudorapidity windows for the data.

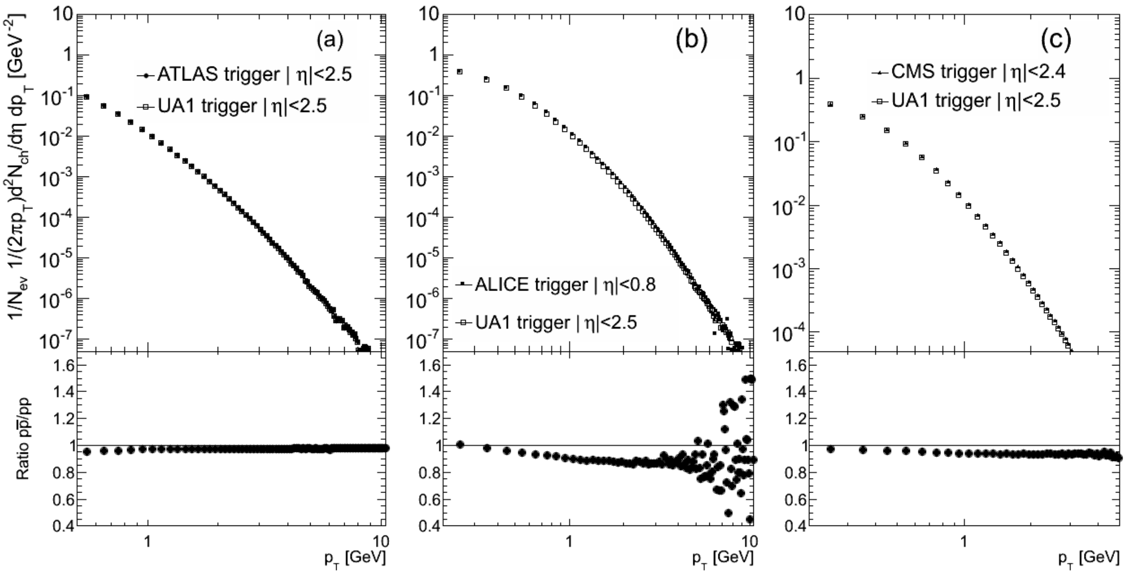

Figure 4: The ratios of invariant inclusive cross sections of the UA1 to ATLAS (a), ALICE (b) and CMC (c) at $\sqrt{s} = 900$ GeV as obtained from one and the same proton-proton event sample but with different trigger requirements **plus the effect of triggers rejection at UA1**. The solid line at 1 is shown to guide the eye

The effect caused by different trigger requirements can also be shown in the pseudorapidity density measurements, Fig. 5. The effect from the UA5 Collaboration trigger lowers the value of pseudorapidity density and no triggers rejection was reported in the UA5 paper [6]. But the actual data are the same for the UA5 and the LHC experiments as can be seen in the insertion in the Fig. 5. The data in Fig. 1 and Fig. 5 are contrary because if the inclusive cross sections are higher for proton-antiproton interaction then the pseudorapidity density also has to be higher for proton-antiproton. It really can be higher, but the effect from the UA5 trigger which allows larger fraction of diffractive events might have suppressed this difference.

It should be noted that all studies of the trigger effects in this report were carried out in one and the same sample of one million generated proton-proton events at energy 900 GeV. We did not use the proton-antiproton simulated events in case of UA1 and UA5 triggers because we have found an ambiguity in treating of proton-proton and proton-antiproton events in the default Pythia. It is shown in Fig. 6 and Fig.7 that in case of default settings the multiplicity distributions and the pseudorapidity densities are different for proton-proton and proton-antiproton non single diffractive events (NSD) at energy 900 GeV.

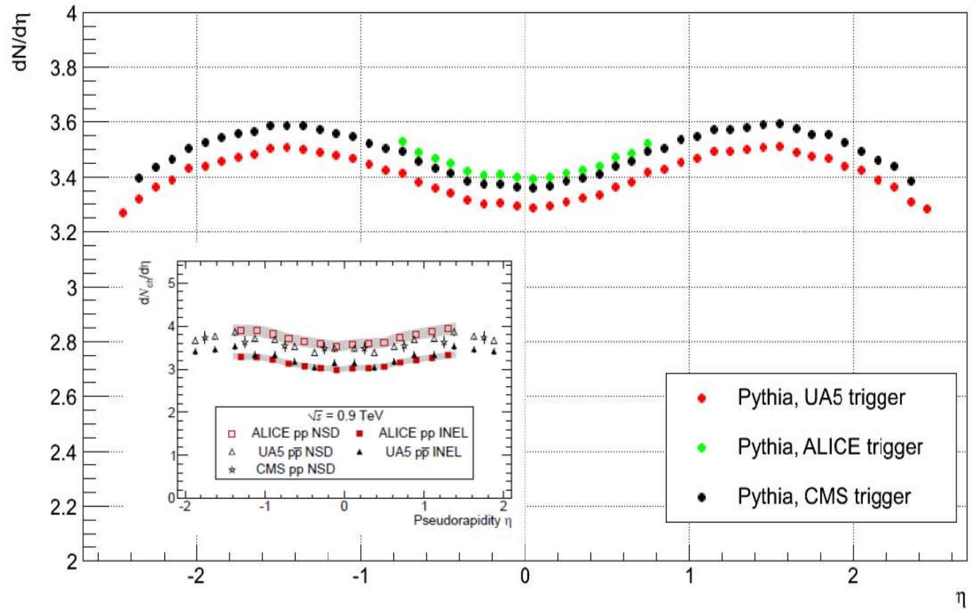

Figure 5: The pseudorapidity density measurements and the trigger effects for the UA5, ALICE and CMS Collaborations.

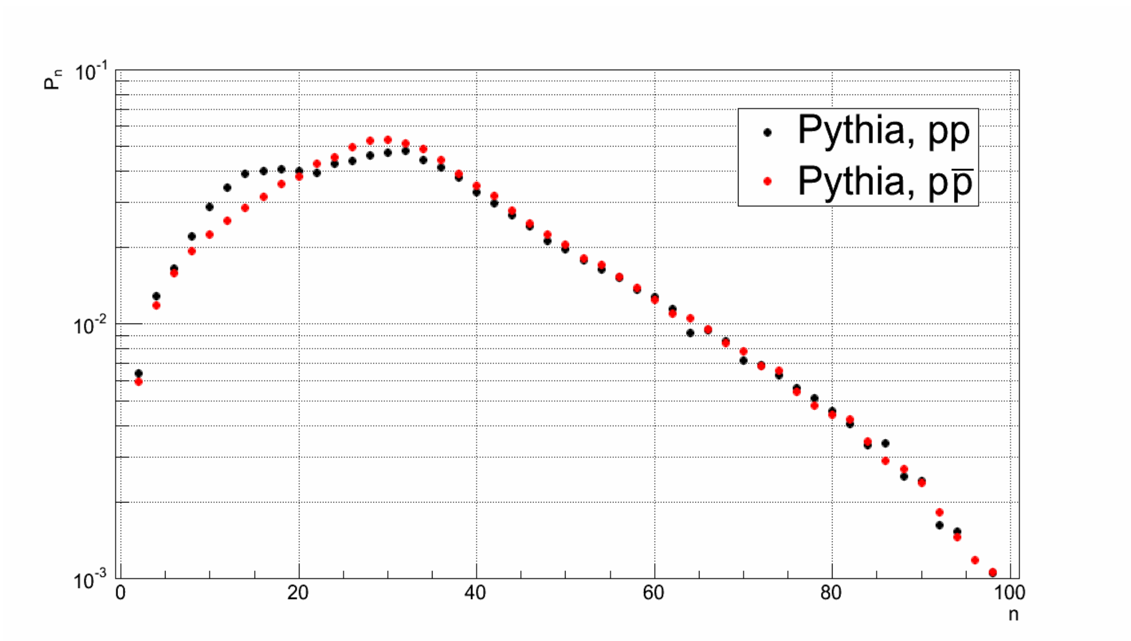

Figure 6: The multiplicity distributions for proton-proton and proton-antiproton NSD events at energy 900 GeV in the default Pythia settings

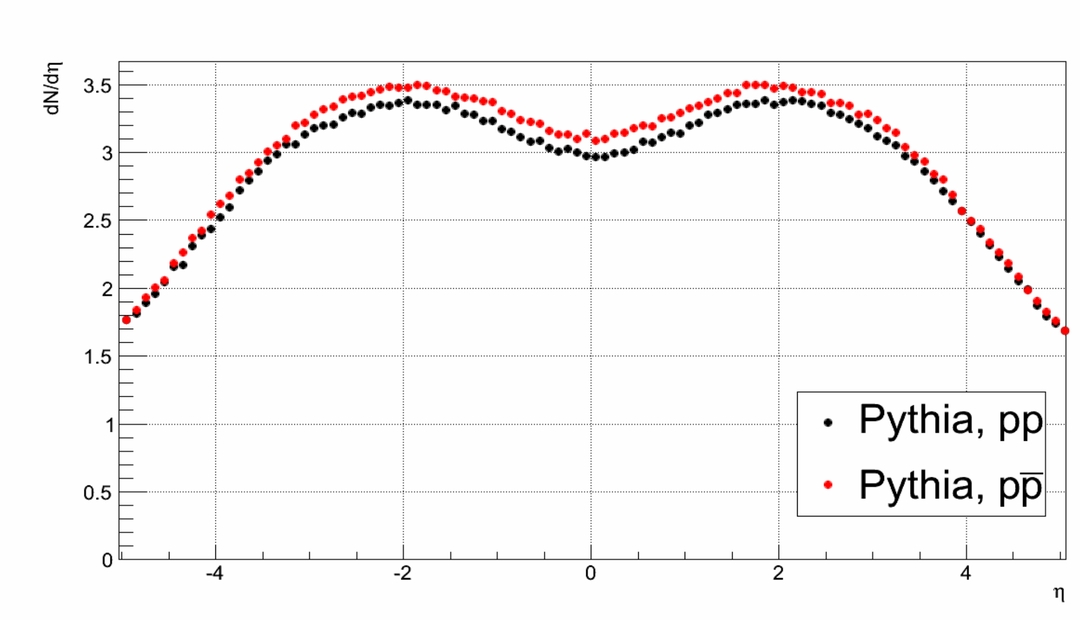

Figure 7: The pseudorapidity densities for proton-proton and proton-antiproton NSD events at energy 900 GeV in the default Pythia settings

4. Conclusions

It is shown that the trigger effects can not explain the difference in inclusive distributions in proton-proton and proton-antiproton data at energy 900 GeV. There is some ambiguity in treating of proton-proton and proton-antiproton scattering in the widely used MC generator Pythia.

5. Acknowledgements

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References

[1] V. Khachatryan et al. CMS Collaboration, JHEP 1002 (2010) 041, arXiv:1002.0621 [hep-ex]

[2] G. Aad et al. ATLAS Collaboration, Phys. Lett. B 688 (2010) 21, arXiv:1003.3124 [hep-ex]

[3] K. Aamodt et al. ALICE Collaboration, Phys. Lett. B 693 (2010) 53, arXiv:1007.0719 [hep-ex]

[4] C. Albajar et al. UA1 Collaboration, Nucl. Phys. B 335 (1990) 261

[5] V.A. Abramovsky and N. V. Radchenko, arXiv:1111.4978 [hep-ph]

[6] G.J.Alner et al. UA5 Collaboration, Z. Phys. C 33 (1986) 1

[7] T. Sjostrand, S. Mrenna, P. Skands, JHEP 05 (2006) 026, hep-ph/0603175

[8] P. Z. Skands, arXiv:0905.3418v1 [hep-ph]

[9] M. Albrow et al., hep-ph/0610012; T. Sjostrand and P. Skands, Eur. Phys. J. C 39 (2005) 129