On lepton pair production in proton-antiproton collisions at intermediate energies and the main backgrounds.

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The lepton pair production via the quark-antiquark annihilation subprocess in collisions of beam antiproton with the proton target at E_{beam} = 14 GeV (which corresponds to the center-of-mass energy of the $p\overline{p}$ system E_{cm} = 5.3 GeV) is studied on the basis of the event sample simulated by PYTHIA6 generator and PandaRoot package. Different kinematical variables which may be useful for design of the muon system and the electromagnetic calorimeter of the detector of PANDA experiment at FAIR, as well as for the study of proton structure functions in the available $x - Q^2$ kinematical region, are considered. The problems due to the presence of fake leptons that appear from meson decays, as well as due to the contribution of background QCD processes and minimum bias events, are also discussed. The set of cuts which allows one to separate the events with the signal lepton pairs from different kind of background events are proposed.

1 Introduction

This intermediate energy experiment (E_{beam} < 15 GeV) may play an important role because it allows to study the energy range where the perturbative methods of QCD (pQCD) come into interplay with a rich physics of bound states and resonances. A detailed and high-precision experimental study at PANDA may allow to discriminate between a large variety of existing nonperturbative approaches and models that already exist or are under development now. Dilepton events may serve as a powerful tool to get out the information about the parton distribution functions (PDFs) in hadrons [1]. The plans to study this process are included into the LoI and TPR of PANDA experiment at HESR. This study may provide an interesting information about quark dynamics inside the nucleon [2]. The results of study of leptons angle and energy spectra distributions, based on this Monte-Carlo simulation, was used for a proper geometrical design of PANDA muon system.

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2 Observations and Interpretation

The work presents the distributions of the most essential kinematical variables of individual leptons from $\overline{p}p \to l^+l^- + X$ (MMT-DY) and benchmark $\overline{p}p \to J/\psi + X$ ($J/\psi \to l^+l^-$) processes. These distributions allow one to estimate the energy, transverse momentum and angle ranges that may be covered by leptons produced in quark-antiquark annihilation process. The PYTHIA6 simulation has shown that one may expect to gain about $7 \cdot 10^7$ MMT-DY events per year for the luminosity $L = 2 \cdot 10^5$ mb^{-1}s^{-1}.

The study of kinematical characteristics of lepton pair as a whole system was also done. The analysis of distributions allowed to determine the region in x-Q^2-plane which can be available for measuring the proton structure function at PANDA: $0.05 \leqslant x \leqslant 0.7$ and $Q^2 \leqslant 6.25$ GeV.

An important problem of background suppresion is also considered. The histograms which demonstrate the relative contribution of different parents and grandparents of produced leptons are presented. According to PYTHIA, the fraction of signal dimuon events which include fake muons is about 16.6%. In a case of electrons the number of signal events fraction containing fake electrons is about 2%. The set of three cuts is proposed which allows to reduce the fraction of the signal events containig fake decay leptons to the values $fr_\mu = 0001\%$ in a case of $\mu^+\mu^-$ production and $fr_e = 0.008\%$ in e^+e^-. Much more dangerous background is caused by minimum-bias and QCD events. The proposed set of five cuts allows to get rid completely of minimum-bias and QCD background contribution in the $\mu^+\mu^-$ case and to reach the value of $S/B = 3.8$ for the e^+e^- case.

It was also noted that the study of events with two (and even three) lepton pairs would allow to improve the precision of the parameters of multiple quark interactions, which measurement will extend the region of QCD studies.

Acknowledgments

I am grateful to my coauthors for useful discussions and proposed topics for investigation. Additional thanks to FAIR-Russia Research Center (together with Federal Agency for Atomic Energy (Rosatom) and Helmholtz Association) for finantial support.

References

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