STUDY OF THE MPD DETECTOR PERFORMANCE IN $p+p$ COLLISIONS AT NICA*

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In this work, the Monte Carlo (MC) simulations of $p+p$ collisions at $\sqrt{s} = 4$–20 GeV have been performed to explore the possibilities of the Multi-Purpose Detector (MPD) to register data from $p+p$ collisions at the energy range of NICA. The events were generated by using the PHSD (Parton Hadron String Dynamics) generator, while the MpdRoot code was used to simulate and reconstruct the generated data. In this paper, a performance analysis of the MPD TPC for $p+p$ at the first stage, as well as an estimation of the charged particle multiplicity is presented.

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1. Introduction

The NICA accelerator will provide colliding beams with masses ranging from protons to gold (Au^{79+}). The collision energy range for Au^{79+} is intended to be $\sqrt{s_{NN}} = 4$–11 GeV per nucleon pair, while for protons is up to 27 GeV. The MPD, which is the main collision detector of NICA, is in design phase and is currently being installed. It has the barrel geometry typical of collider detectors [1]. The installation and tests of TPC (Time Projection Chamber) as the main tracking detector of MPD are scheduled to finish in 2020. Basic measurements of $p+p$ collisions are required as a benchmark for heavy-ion collision measurements and to obtain a better understanding of light collision systems.

2. Simulation of the MPD TPC

The PHSD code [2] was selected to generate events with single head-on inelastic $p+p$ interactions. Since the partonic phase is not dominant at the

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energies available in NICA, the generator was used in HSD mode which does not have the QGP phase transition. The framework used to perform this analysis was the dedicated software MpdRoot, where the MC step makes use of Geant3 or Geant4 to propagate particles through the detector materials, simulated as realistic as possible. Digitized detector signals are processed by the cluster/hit finding procedures to produce reconstructed points which serve as an input to the Kalman filter-based track reconstruction program. Reconstructed Kalman tracks are used by the vertex finding procedure. The reconstructed tracks are associated with their corresponding MC particle [3].

2.1. Performance of TPC

This section briefly describes the simulations to study the performance of the TPC in $p+p$ collisions.

Events with at least one charged track reconstructed in TPC were analysed without applying fiducial cuts in order to know the TPC reconstruction efficiency. It was found that 75% of events had at least one track reconstructed in the TPC meaning that 25% of events were "empty" independent of the collision energy.

The efficiency to measure charged tracks in the acceptance region of TPC, for primary and secondary tracks, is shown in Fig. 1. Its dependence on p_{T} and η is represented in the left and right panel, respectively. All charged particles were taken into account. The tracking efficiency was defined as the ratio of found tracks with more than 50% hits from the same particle to all generated primary particles. The number of space points to form a track in TPC was required to be larger than 10. The sample of secondary particles includes the particles produced within 50 cm from the primary vertex, both in longitudinal and transverse directions. The tracking efficiency for the simulated sample of all charged particles drops below 50% for $p_{\mathrm{T}} < 0.1$ GeV$/c$. Low-p_{T} particles usually do not reach the active vol-

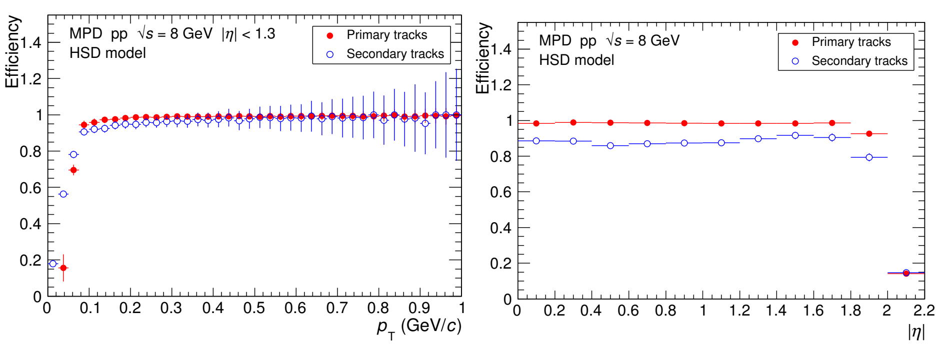

Fig. 1. Efficiency to track primaries and secondaries in TPC as a function of p_{T} (left) and as a function of $|\eta|$ (right).

ume of TPC. The tracking efficiency approaches 100% for $p_{\rm T} > 0.2$ GeV/c. In most of the TPC acceptance, the efficiency approaches 100% for primary particles and 90% for secondaries, becoming degraded at the extreme η values.

The level of contamination was also studied. It was found that "clone" tracks (having more than 50% of hits from the same particle) contributed less than 1% for all the $p_{\rm T}$ range, except at $p_{\rm T} < 0.2$ GeV/c around mid-rapidity, where its contribution was $\sim$ 10% due to effect of the TPC membrane at $Z = 0$. For $|\eta| > 1.2$, the contamination dropped to zero. The "clone" tracks were mainly the result of the track splitting at the TPC sector boundaries or low-$p_{\rm T}$ track branching due to spiraling. The contribution of "ghost" tracks (having less than 50% of hits from the same particle) was found to be negligible in our study of $p+p$ collisions generated with the HSD model at $\sqrt{s} = 8$ GeV.

The primary vertex resolution as a function of the number of reconstructed tracks is shown in Fig. 2. It was defined as the standard deviation extracted from the Gaussian fits of the vertex coordinates for discrete track multiplicities. The event multiplicity and the $p_{\rm T}$ of tracks used for the

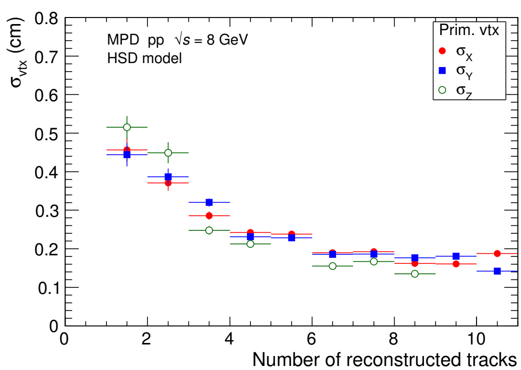

Fig. 2. Primary vertex position resolution as a function of the track multiplicity.

primary vertex determination largely determine its resolution. In the acceptance region of the TPC, the resulting primary vertex resolution was better than 2 mm for multiplicities of more than 6 TPC tracks. The $p_{\rm T}$ resolution ($\delta_{p_{\rm T}}$) was analysed in this work considering all charged primary particles reconstructed in the TPC. It was defined as the standard deviation of the Gaussian fits of the relative differences between $p_{\rm T_{MC}}$ and $p_{\rm T_{rec}}$. The left panel of Fig. 3 shows the $p_{\rm T_{MC}}$ dependence of $\delta_{p_{\rm T}}$, while $\delta_{p_{\rm T}}$ *vs.* $|\eta|$ is shown in the right panel. The best $p_{\rm T}$ resolution is 1.7% for $p_{\rm T_{MC}} = 0.35$ GeV/c and is lower than 2.6% in the interval $p_{\rm T_{MC}} = 0.1 \div 1.5$ GeV/c. For

$p_{\mathrm{T_{MC}}} > 1.5$ GeV$/c$, the statistics is poor. The same p_{T} resolution is observed in the pseudorapidity range up to $|\eta| = 1.1$. For larger $|\eta|$ values, the p_{T} resolution is degraded.

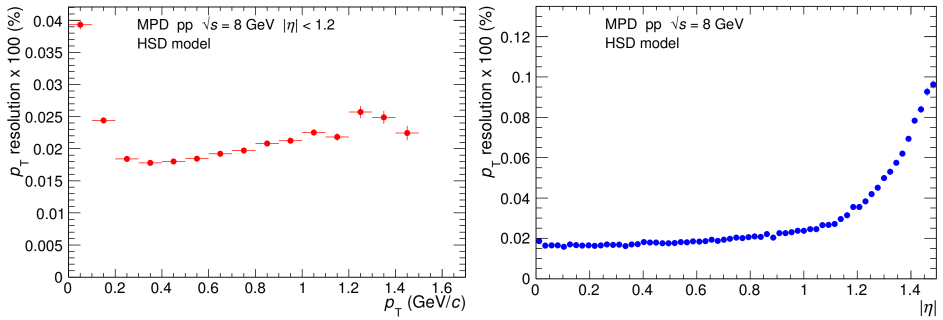

Fig. 3. Transverse momentum resolution as a function of p_{T} (left) and $|\eta|$ (right).

Taking the charged-particle p_{T} and η-density distributions ($i.e.$ $\mathrm{d}N_{\mathrm{ch}}/\mathrm{d}p_{\mathrm{T}}$ and $\mathrm{d}N_{\mathrm{ch}}/\mathrm{d}\eta$) for different $\sqrt{s}$ values, the multiplicity of charged particles registered in the TPC was estimated. After a normalization to all events with at least one TPC reconstructed track, the average multiplicity $\langle N_{\mathrm{ch}}\rangle$ as a function of the collision energy $\sqrt{s}$ was obtained. This is shown in Fig. 4.

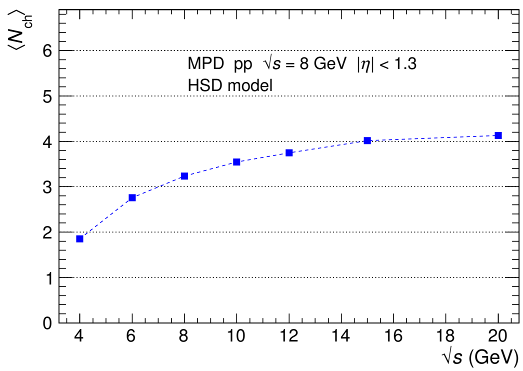

Fig. 4. Average multiplicity in the acceptance region of the TPC.

3. Conclusions

Our analysis revealed a good tracking efficiency and momentum resolution, as well as a good performance in the primary vertex determination considering the TPC-only tracks. This allows to apply the proper corrections in the analysis of different observables from the reconstructed data.

Further studies are ongoing with the aim to compare different event generator predictions for $p + p$ collisions at the collision energies expected to be studied with MPD in NICA.

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