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Stopping of protons in pA collisions at SPS and NICA energies in analytical hydrodynamic model and in SMASH event generator

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Our study is motivated by the first experimental results on pion production and stopping obtained in pA collisions in E910 experiment at BNL [1]. The effect of stopping is the decelera-tion of an incident high energy proton traversing the target nucleus. It appears due to the energy losses relevant to the production of secondary particles in the inelastic interactions with nucleons. The effect is related to the number of inelastic nucleon-nucleon scatterings (N_{coll}), suf-fered by the projectile, and the last quantity was estimated in [1] by the measurable number of so-called "grey" particles –products of the recoil nucleon shower induced by the incoming pro-ton. The multiplicity ($<N_{ch}>$) of negatively charged pions (π^-) as a function of N_{grey} demonstrated some peculiarities, in particular, deviation from linear was observed for large values of N_{grey} [1].

We have proposed previously a hydrodynamic effective model of stopping based on the consid-eration of the nuclear matter as a liquid and by the introduction of an effective stopping force acting on a proton [2]. With this force we obtain a differential equation that describes relativistic motion of a proton in a nucleus. Setting the final speed - the speed after which binary collisions do not contribute to multiplicity - we calculate the length of the proton's path in the nucleus. This path length cuts out a region, in the nucleus to which we apply the Glauber-like approach to ob-tain number of binary collisions. We obtained in the framework of this model the dependencies on the impact parameter for such quantities as pion multiplicity, the number of binary nucleon-nucleon collisions and the correlation function $<N_{ch}>$ vs. N_{grey}.

In this report, results on the correlation between mean multiplicity and a number of grey nucle-ons are compared to the available experimental data on centrality dependence of stopping and π^- production in p+Au and p+Cu collisions at a beam momentum of 18 GeV/c [1]. The de-pendencies $N_{ch}(b)$, $N_{bin}(b)$, $N_{\pi^-}(N_{grey})$ in the collisions of high energy pro-tons with gold and with cuprum nuclei are also considered using SMASH [3] event generator. A comparison of the MC simulations with analytical hydrodynamic model calculations is also per-formed and results are discussed in view of binary collision estimates needed for the future SPS and NICA experiments.

[1] I. Chemakin et al., Phys. Rev. C 60, 024902; https://doi.org/10.1103/PhysRevC.60.024902; arXiv:nucl-ex/9902009

[2] V.Ermakova et al., Abstract of the talk presented for NUCLEUS-2020 conference, to be published

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