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Proton stopping in a hydrodynamic model of pA collisions at SPS and NICA energies

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We study the phenomenon of high energy proton stopping in the nuclear matter and suggest the effective model that describes this effect. To compare our model with the data of relatively low energy experiment [1] we use the correlation between mean multiplicity and number of so-called grey nucleons - particles, which are knocked out of the nucleus by the incoming proton.

Proton decelerates in the nuclear matter transferring its energy to the production of new particles in inelastic interactions. We introduce the stopping force from hydrodynamics to explain this deceleration in an effective way. The idea is to treat target nuclei as a liquid drop with given internal energy density and volume. As soon as the projectile-proton gets into the target-nuclei the stopping force begins to act on it. 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 obtain number of binary collisions. (Note that in a pure Glauber approach, the integration extends to the entire space.) The method of calculating dependency of mean multiplicity on impact parameter is also suggested. As an input in this model we use empirical dependency of mean multiplicity on energy in pp-collisions [2] and values of σ_{inel}^{NN} [3].

Results on the correlation between mean multiplicity and a number of grey nucleons are compared in this work to the available experimental data on centrality dependence of stopping and π^- production in p-Au collisions at a beam momentum of 18 GeV/c [1]. The linear dependence of the correlation between mean multiplicity and grey nucleons predicted by the model is well in line with the experimental data obtained at low numbers of grey nucleons. At the same time, it is shown that the limited acceptance of pion registration can produce a strong deviation from the linearity as observed in the experiment with slow protons at large values of pion multiplicity and number of grey nucleons.

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[2] W.Thomé, K.Eggert, K.Gibini [etc.] // Nuclear Physics B129. P. 365-389. doi:10.1016/0550-3213(77)90122-5
[3] P.A. Zyla et al. (Particle Data Group), to be published in Prog. Theor. Exp. Phys. 2020, 083C01 (2020), https://pdg.lbl.gov/2020/hadronic-xsections/hadron.html

Primary author: ERMAKOVA, Vera

Co-authors: Dr PUCHKOV, Andrei (Saint Petersburg State University); Dr FEOFILOV, Grigoriy (SPbSU); Prof. VECHERNIN, Vladimir (SPbSU); Dr KOVALENKO, Vladimir (St Petersburg State University (RU))

Presenter: ERMAKOVA, Vera

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