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The Triple Nuclear Collisions Method opens a new frontier to investigate the QCD matter properties at ultrahigh baryonic charge densities

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In a few years the experiments with high luminosity (HL) beams will start at the Large Hadron Collider (LHC). Among the other opportunities for such experiments, there are plans to exploit the fixed target mode for HL beams [1]. Using this opportunity, here we suggest to perform the entirely new experiments by means of utilizing the scattering of the two colliding beams at the nuclei of a solid target which is fixed at their interaction region. An original feature of the suggested experiments is a usage of the super-thin solid target operated in the core of colliding beams [2, 3, 4]. Such an approach is based on the successful data-taking process in the LHCb experiment in which the colliding and fixed gaseous target modes are running simultaneously.
Our estimates show that for the instantaneous luminosity of colliding proton beams at HL LHC of L= 10^{36} 1/cm^2/s and the fixed carbon target of the geometrical thickness of 3.3 μm that fills the interaction region of two colliding beams one can expect the triple nuclear collision rate to be about 2 events per 1000 s. For the luminosity of lead beams L= 10^{33} 1/cm^2/s hitting the lead fixed target of similar characteristics one can find that the number of triple nuclear collisions is about 3.4 per 10000 s.
To elucidate the distinctive features of the triple nuclear collisions, we used the UrQMD 3.4 model [5, 6] for the beam center-of-mass collision energies √s = 2.76 TeV and √s = 200 GeV. Our simulations show that in the most central and simultaneous triple nuclear collisions the initial baryonic charge density is about 3 times higher than the one achieved in the usual binary nuclear collisions at these energies. Contrary to the binary nuclear collisions, we found that the high value of baryonic charge density leads to a strong enhancement of proton and Λ-hyperon production at the midrapidity and to a sizable suppression of their antiparticles. Also in such experiments an entirely new kind of scattering reactions, namely a nucleus-fireball interaction, can be studied. Our preliminary simulations shown that the triple nuclear collision method at lower energies of collisions can be of principal importance to discover the (tri)critical endpoint of the QCD phase diagram [4].

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