Exploring spectator neutrons as a probe of the initial nuclear momentum distribution in relativistic heavy-ion collisions

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Nucleon-nucleon short-range correlations (SRC) provide a unique window into the short-distance behavior of the nuclear force and beyond-mean-field dynamics in nuclear many-body systems. They generate a universal high-momentum tail in the nuclear momentum distribution and are dominated by neutron-proton pairs [1, 2]. In this poster, we explore a new experimental approach for probing these features using free spectator neutrons at forward rapidity in relativistic heavy-ion collisions [3, 4]. Since the longitudinal momentum of a spectator is dominated by the beam momentum, while its initial transverse momentum is approximately preserved, its transverse displacement measured at the Zero Degree Calorimeter (ZDC) is correlated with its initial transverse momentum. Thus, the transverse hit position ($r_\perp$) can serve as a proxy for the initial transverse momentum (p_T). We analyze 0–5% ultra-central ^{96}Ru + ^{96}Ru and ^{96}Zr + ^{96}Zr collisions at $\sqrt{s_{NN}} = 200$ GeV by STAR, using the ZDC with a single-neutron selection calibrated by ultra-peripheral collisions. The differential spectator-neutron yield ratio, $N_n^{\mathrm{Zr+Zr}}(r_\perp)/N_n^{\mathrm{Ru+Ru}}(r_\perp)$, is studied as a function of $r_\perp$, including the region corresponding to transverse momenta above the Fermi momentum. The relative yield at large $r_\perp$ provides sensitivity to the high-momentum components of the nuclear momentum distribution, including possible contributions from neutron-proton SRC pairs. The measured ratios are compared with model expectations. This exploratory study investigates the potential of spectator-neutron deflection as a probe of the initial nuclear momentum distribution.

References

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