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Study of Di-hadron correlations of heavy ion collisions at NICA energies using maximum transverse momentum method

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Abstract

Di-hadron angular correlations are a useful tool to study the mechanisms of particle production by observing the angular separation ($\Delta\eta$, $\Delta\varphi$) between pairs of particles in an event. Different structures in the $\Delta\eta - \Delta\varphi$ space are caused by various modes of particle production and interactions between particles shortly after production. Examining these structures can give us insight into the nature of these interactions. One of these structures is called "the Ridge"

The Ridge-effect phenomenon was first reported in the STAR collaboration at RHIC as decomposition of the distribution of interacting particles into jet and flow components (figure 1). The ridge effect can be characterized by the values of azimuthal and pseudorapidity differences $\Delta\eta \times \Delta\varphi$ for fitted transverse impulse intervals for both trigger and associated particles. The study of the ridge effect with method of maximum transverse momentum, which is a global characteristic of the entire event, makes it possible to more clearly describe the jet and stream components on the distribution map.

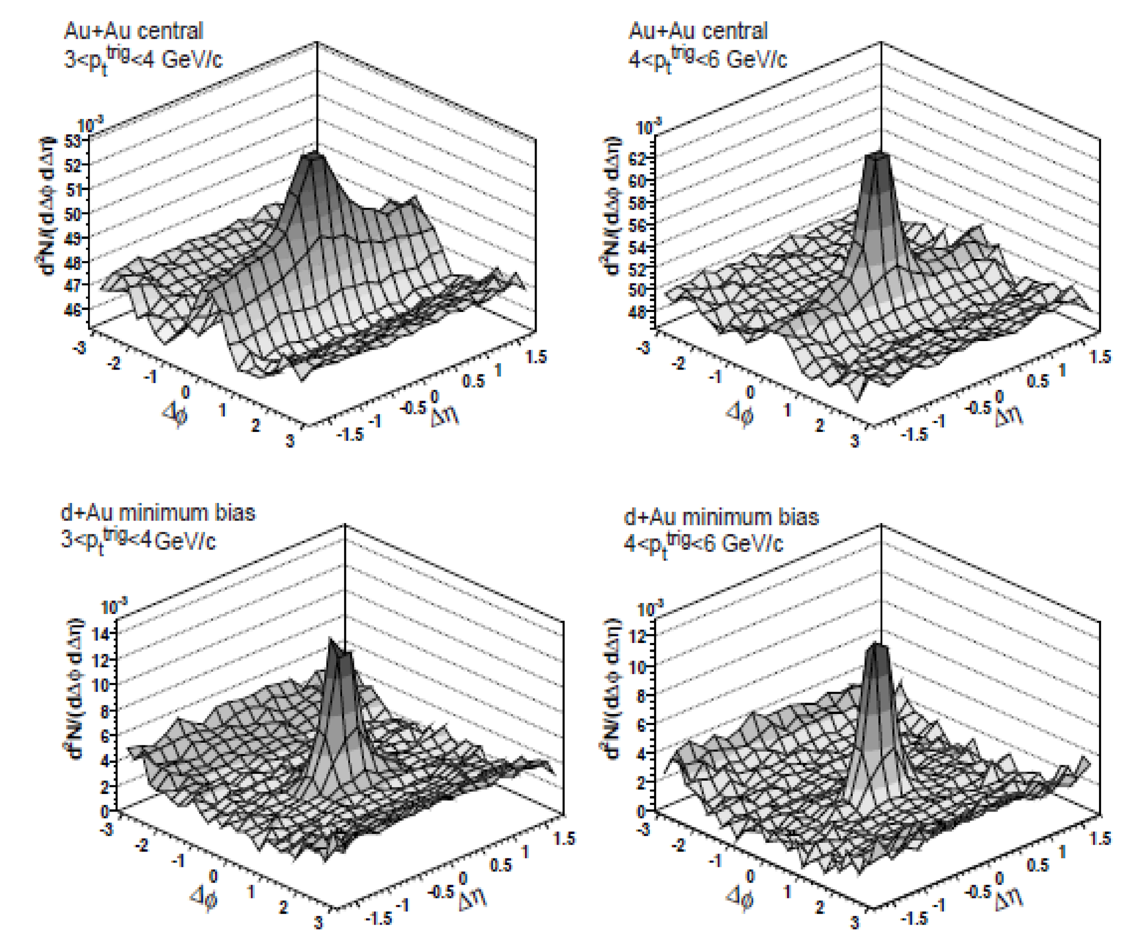

Figure 1. Au+Au di-hadron dist.UL central 3-4 Gev/c; UR central 4-6 Gev/c; LL min bias 3-4Gev/c; LR min bias 4-6 Gev/c

NICA (Nuclotron based Ion Collider fAcility)

The main goal of studying heavy ion collisions is to study the properties of nuclear matter under extreme conditions of density and temperature. However, the region of the QCD phase diagram with nonzero baryon densities has not yet been explored for the most part. A new experimental program at the NICA accelerator complex at JINR in Dubna (figure 2) is designed to fill this gap by performing a comprehensive study of dense nuclear matter in the collision energy range $\sqrt{s_{NN}} = 4-11$ GeV[1].

The major experiment at NICA collider rings is MPD. It is designed to detect charged hadrons, electrons and photons in 4π space, produced by collisions of heavy ions in the energy range and high luminosity of the NICA collider[2].

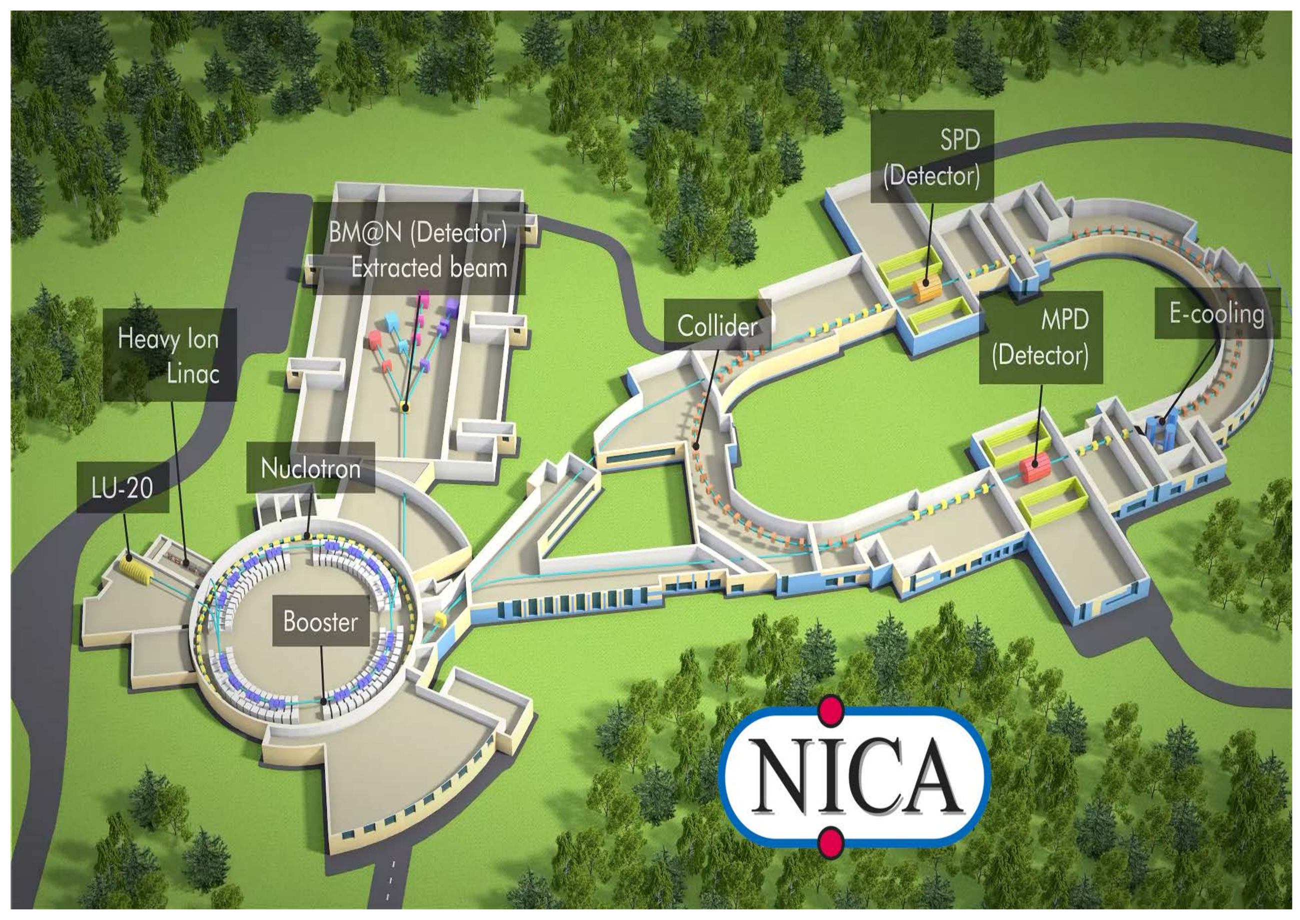

Figure 2. NICA megaproject concept design.

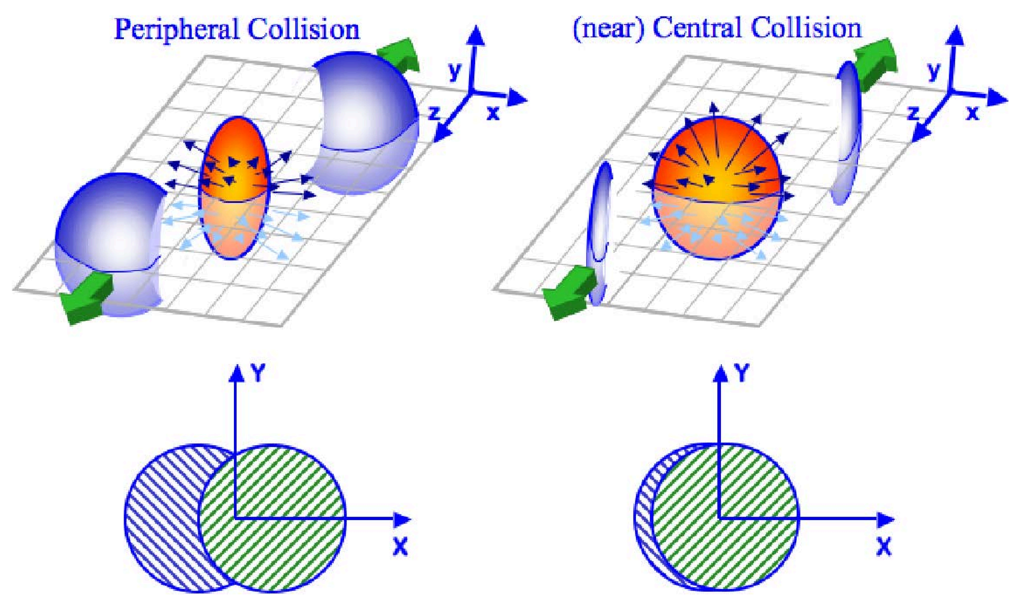

Figure 3. Almond shaped impact region resulting from a semicentral heavy ion collision and momentum space

Di-hadron correlations of heavy ion collisions

In heavy ion collisions even at low energies many particles are produced. Main feature in the distributions of these particles is the appearance of their collective behavior - flows.The flow in the transverse plane can be separated into a radial and an anisotropic flow.

The radial flow is the component of the flow that describes the isotropic expansion of the particles. The anisotropic flow is the more interesting of the two components. It measures the momentum space anisotropy of particle emission as a function of the azimuthal angle. This anisotropy arises from the fact that not all collisions occur perfectly centrally and so the overlapping parts of the two colliding nuclei do not form a round shape when looking along the beam line, but an almond shape[4]. A schematic illustration of this can be seen in figure 3.

The "Ridge" effect

The Ridge-effect evidence is called as correlation structure with emphasis on the $\Delta\eta$ shape and high-p_T trigger particles from Au +Au and d+Au collisions at $\sqrt{s_{NN}} = 200$ GeV at STAR experiment[3]. In central Au+Au collisions, significant associated yield at large $\Delta\eta$ is observed for all p_T^{trig}, including $p_T^{trig} > 6$ GeV/c where jet fragmentation is expected to be the dominant particle production mechanism. At large p_T^{trig} the near-side correlation structure can be factored into a jet-like peak, with properties similar to correlations in nucleon-nucleon collisions (figure 4).

It was shown that more detail study of such effects with the using distribution for all particles transverse momenta as a function of global event variable p_T^{max} [5]. So we would like to investigate in this work the distributions of particles, which will be produced at NICA energies, with the using of the global event variable p_T^{max}.

For the study 1 millions of events of Au+Au collisions at energies 4, 7, 9, 11 GeV were generated with DCQGSM model. The collision system in this simulation consists of two Au ions colliding head-on along a single axis. Each collision is an independent and an isolated system,so there are many quantities that should be conserved. The momentum conservation influences the shape of the correlation function, especially in collisions with fewer produced particles. For momentum in the transverse plane to be conserved, for each particle leaving the interaction point in one direction (φ) we expect a deficit of particles going in the same direction and an excess of particles going in the opposite direction.

The illustration of p_T distribution of impact parameter b (figure 4 top), p_T^{max} distribution of impact parameter and Δp_T^{max} transverse momentum distribution (figure 4 bottom), the p_T^{max} distribution of all p_T (figure 5) provide new and interesting details of the formation of jet and flow components of the chosen set of ion collisions.

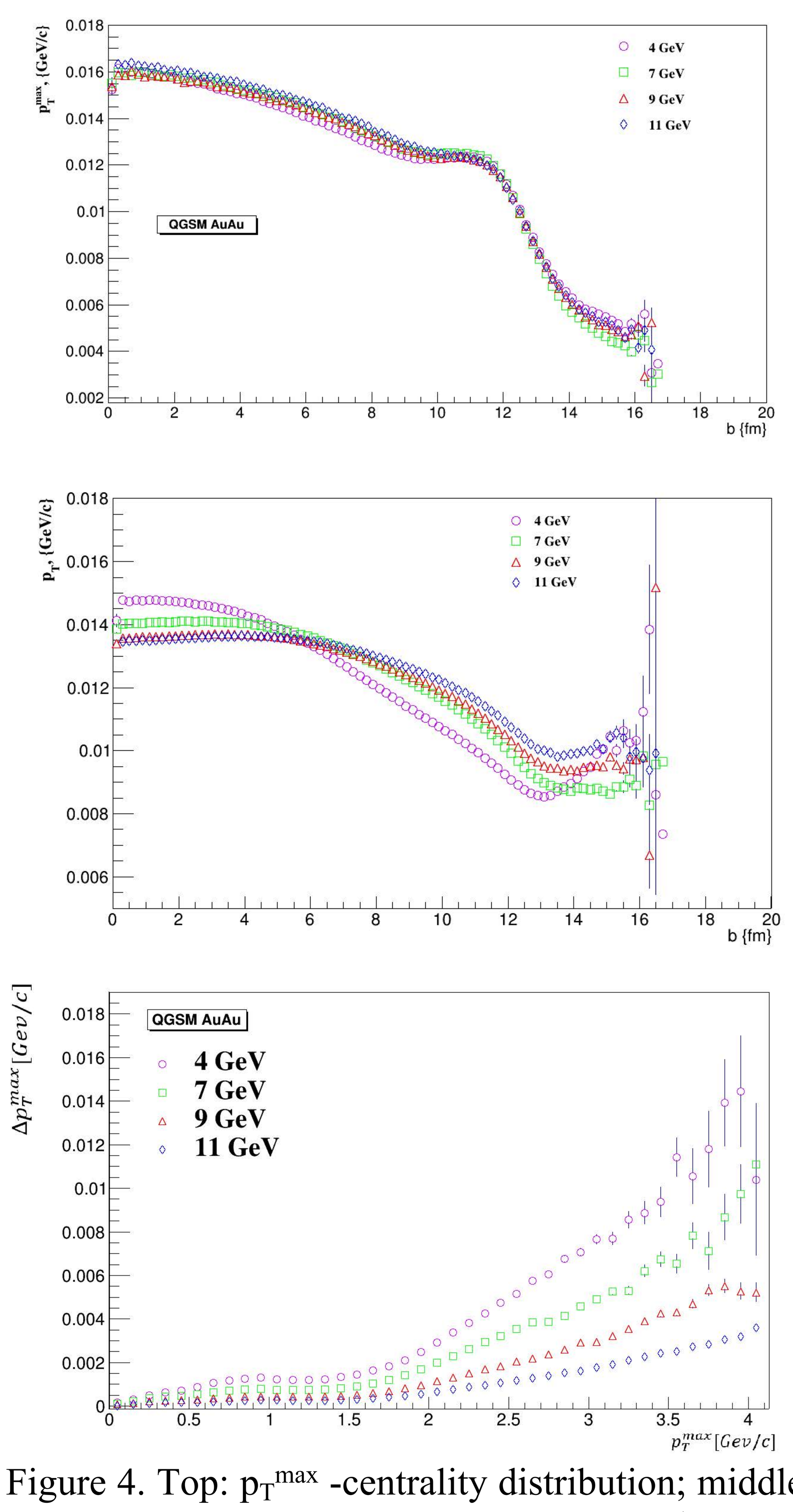

Figure 4. Top: p_T^{max} -centrality distribution; middle:p_T -impact param. dist.; lower: $\Delta(p_T^{max} - p_T^{max-1})$

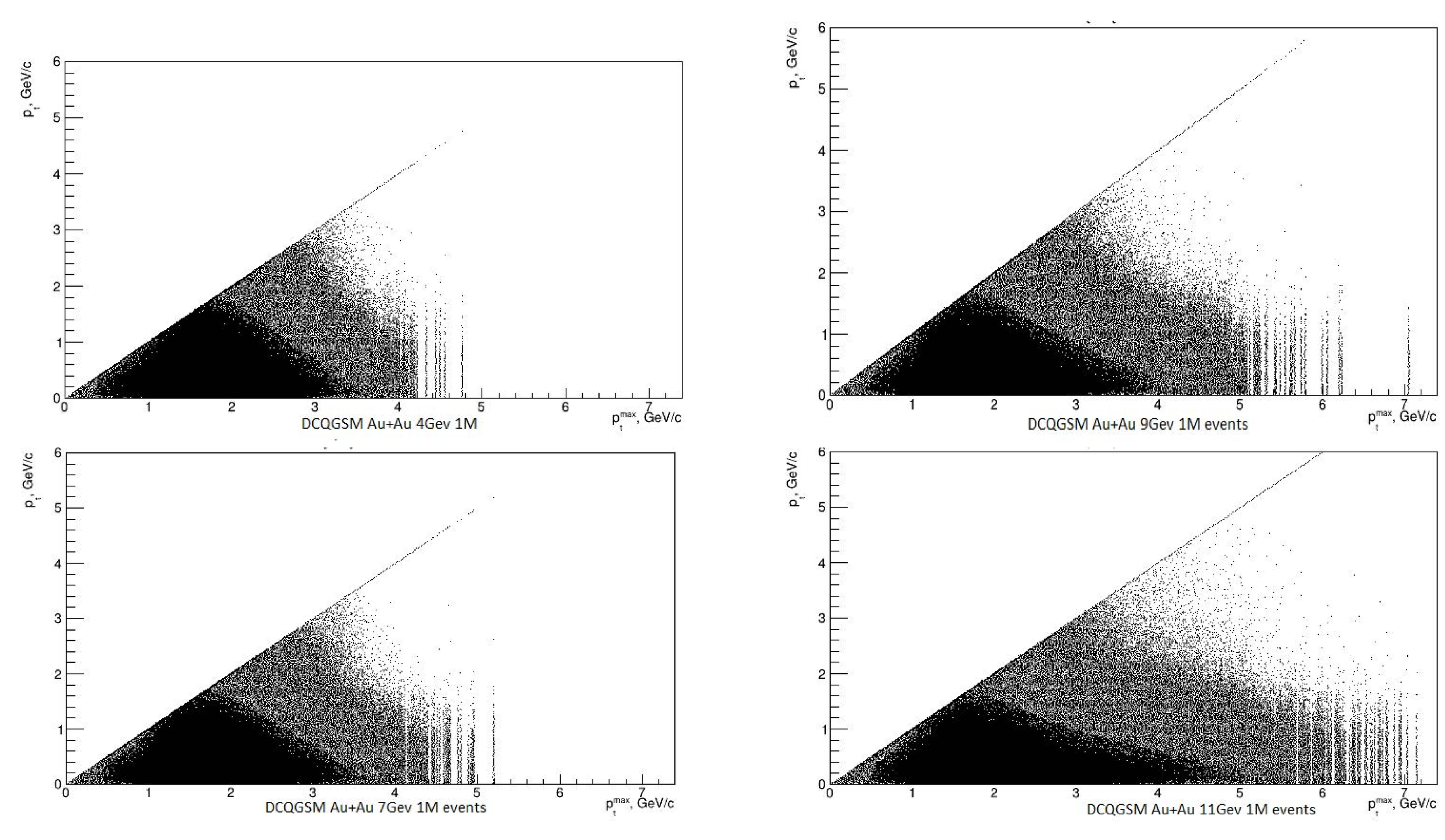

Figure 5. Transverse maximum momentum p_T^{max} distribution map

References:

1. D. Blaschke, J. Aichelin, et al. Searching for a QCD mixed phase at theNuclotron-based collider facility (NICA White Paper), v5.01, 2011
2. A.N. Sissakian, A.S. Sorin, V.D. Kekelidze The MultiPurpose Detector – MPD to study Heavy Ion Collisions at NICA (Conceptual Design Report), v 1.4.
3. B. I Abelev et al. Long range rapidity correlations and jet production in high energy nuclear collisions, STAR collaboration, 2007, Phys. Rev. C 75, 054913
4. Long-range and short-range dihadron angular correlations at √sNN = 2.76 Tev. CMS collaboration, 2011. arXiv:1105.2438v1
5. O. Rogachevsky Study of the multiparticle events structure with fractal geometry methods. Nuclear Physics B (Proc. Suppl.) 219–220 (2011) 305

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