COMSATS Institute of Information Technology

Some properties of the central heavy ion collisions

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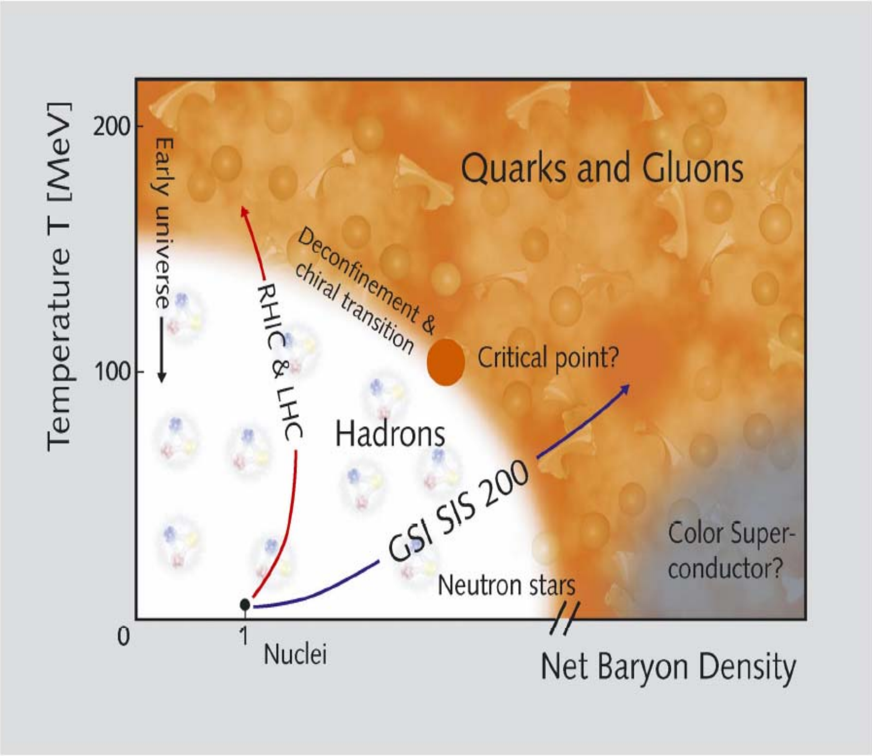
Introduction

Studying of the centrality dependence of the characteristics of hadrons-nuclear and nuclear-nuclear interactions is an important experimental way for obtaining information on phases of strongly interacting matter formed during the collision evolution.

Phase diagram of strongly interacting matter



L. Wan Hove may be first man who tried to use the centrality to get the information on the new phases of matter [L.Wan Hove.Ref.TH.3391-CERN, 1982, CERN]

Wan Hove tried to explain the fact as a signal on deconfinement in hot medium and formation of the Quark Gluon Plasma (QGP).

Review of Literature

Here is the short list of papers coming from the central experiments:

C.Alt, et al. Phys.Rev.Lett. 94 (2005) 052301;S. S. Adler, et al., Phys. Rev. Lett. 91

(2003) 182301; I.Chemakin et al. The BNL E910 Collaboration, 1999, nucl-ex/9902009

Ron Soltz for the E910 Collaboration, J. Phys. G: Nucl. Part. Phys., 2001, 27, pp. 319–326

O.B.Abdinov et al. Bulletin of the Russian Academy of Sciences. Physics , 2006

A. Abduzhamilov et al., Z. Phys. C 40, 223 (1988)

M. K.Suleimanov et al., Phys.Rev.C, 1998, 58, pp. 351

Fu-Hu Liu et al., Phys. Rev. C, 2003, 67, p. 047603

F. H. Liu, Chin, J. Phys. (Taipei), 2002, 40, p. 159

A. L. S. Angelis et al. The HELIOS/3 Collaboration, Eur. Phys. J. C, 2000, 13, pp. 433-452

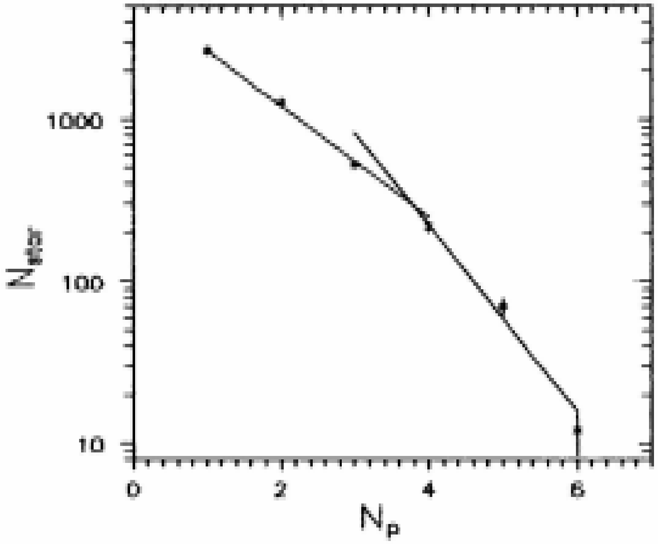
M.C. Abreu et al., Phys.Let. B 1999, 450, p. 456

M.C. Abreu et al., Phys.Let. B,1997, 410, p. 337

M.C. Abreu et al. Phys.Let. B, 1997, 410, p. 327

M. C. Abreu et al. By NA50 Collaboration, Phys.Lett.B, 2001, 499, pp. 85-96

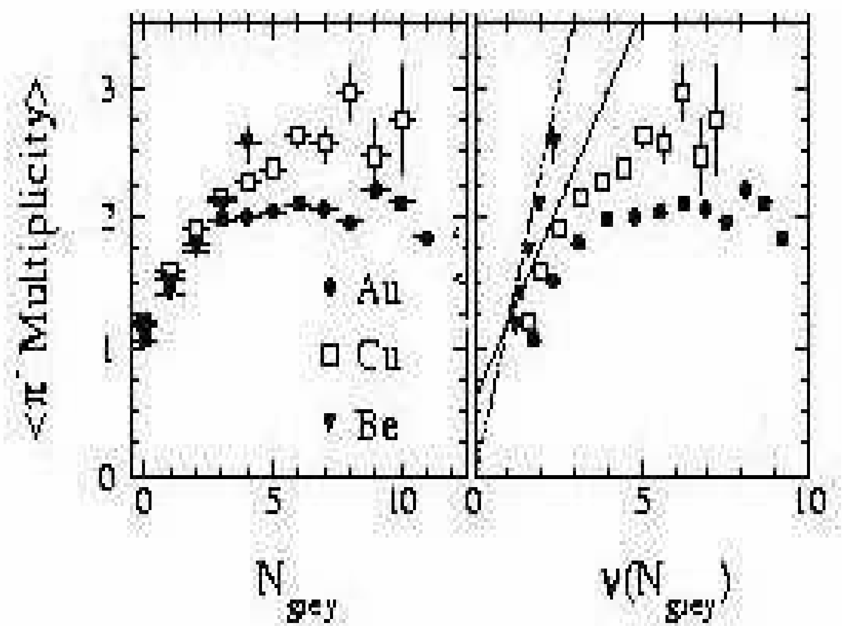
Hadrons-Nuclear Interactions



This picture demonstrated a number of the π^{12}C-interactions (N_{star}) as a function of the number of identified protons N_p.

[18. O.B. Abdinov et al. JINR RC, 1996, No 1[75]-96 p.51.].

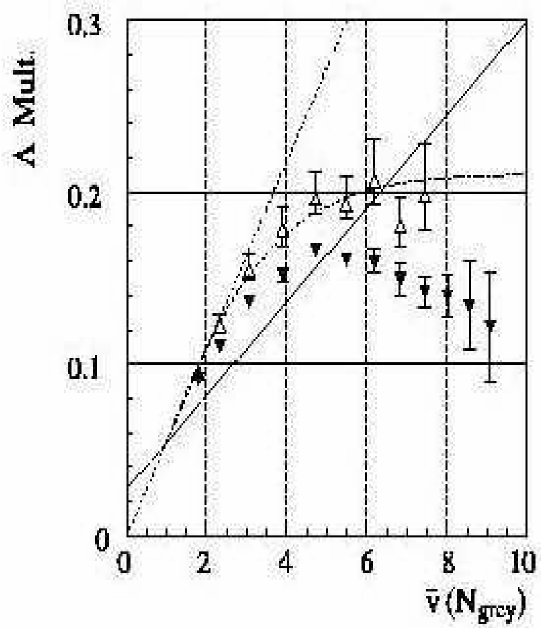
The values of Np was used to fix the centrality in this experiment.



The results from BNL experiment E910 on pion production and stopping in proton-Be, Cu, and Au collisions as a function of centrality at a beam momentum of 18 GeV/c

[I. Chemakin et al. The BNL E910 Collaboration, 1999, E-print: nucl-ex/9902009]

The centrality of the collisions is characterized using Ngrey, and a derived quantity ν

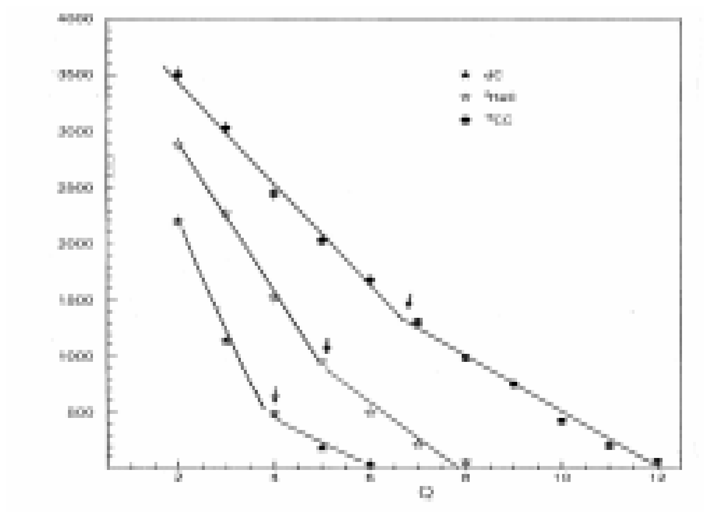


BNL E910 has measured Λ production as a function of collision centrality for 17.5 GeV/c p–Au collisions [*Ron Soltz for the E910 Collaboration, J. Phys. G: Nucl. Part. Phys., 2001, 27, pp. 319–326*].

Collision centrality is defined by ν.

The same result have been obtained by BNL E910 Collaboration for K^0_s and K^+ - mesons emitted in p+Au reaction.

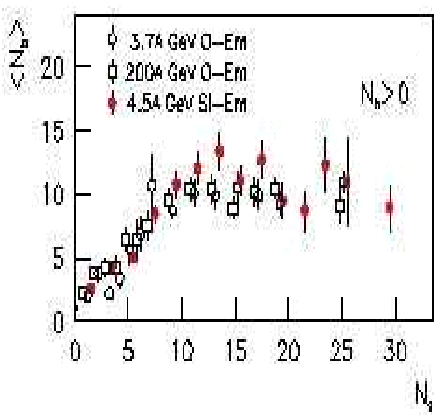
Nuclear-Nuclear Interactions



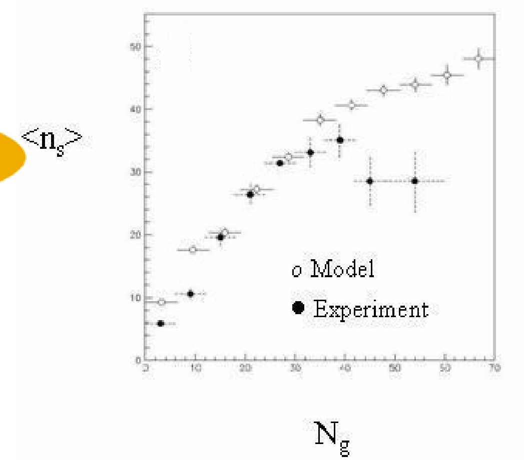
the behavior of the event number as a function of centrality for light nuclei interactions: results for dC, HeC and CC-interaction at 4.2 A GeV/c

[Preprint JINR 1-12114,1979; 1-12424, 1989, P1-98-292,; M. K.Suleimanov et al., Phys.Rev.C, 1998, 58, pp. 351.]

These point of regime change could be used to select the central collisions .



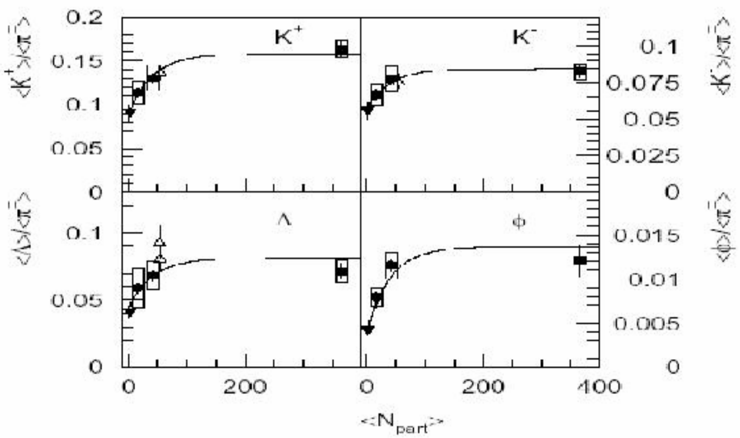
The values of the Ng were used to fix the centrality in those experiments.



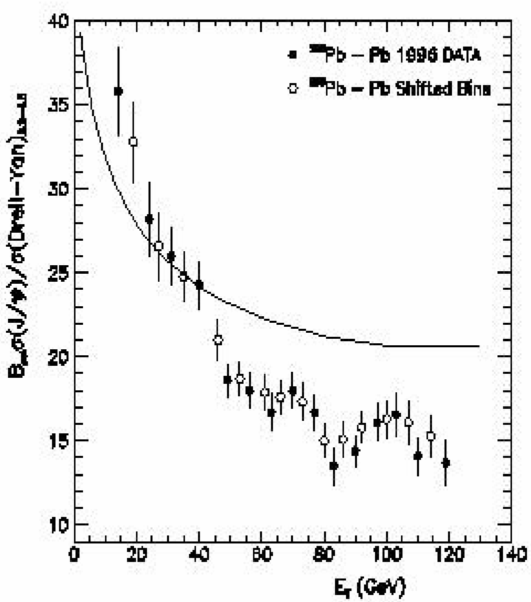
N_g –dependences of $< N_b >$ for different reactions. [*Fu-Hu Liu et al.*, Phys. Rev. C, 2003, 67, p. 047603].

The average values of multiplicity <ns > for s - particles produced in Kr + Em reactions at 0.95 GeV/nucl as a function of centrality [O.B. Abdinov et al. Bulletin of the Russian Academy of Sciences. Physics, 2006].

Heavy Ion Collisions



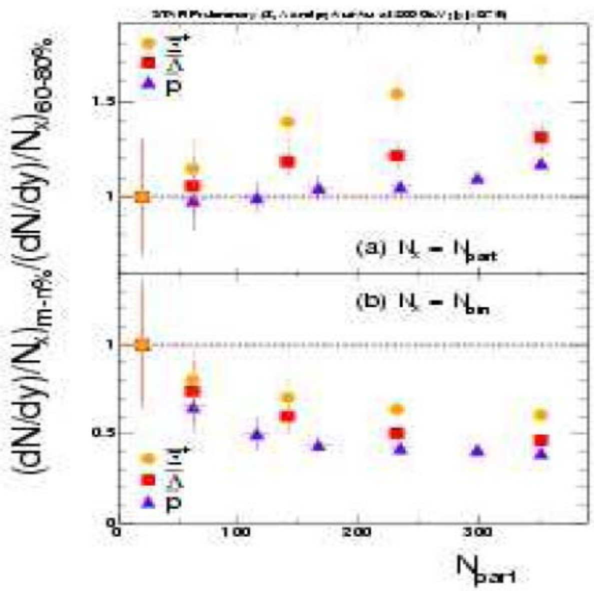
Experimental ratios of <K+>,<K->,φ, and Λ to <π±> plotted as a function of system size (▼ p+p, C+C and Si+Si, ● S+S, ■ Pb+Pb).*[C.Alt,et al. Phys.Rev.Lett. 94 (2005) 052301]*



The ratio of the J/ψ to Drell-Yan cross-sections has been measured by NA38 and NA50 SPS CERN as a function of the centrality of the reaction estimated, for each event, from the measured neutral transverse energy Et [*M.C. Abreu et al., Phys.Let. B 1999, 450, p. 456; M.C. Abreu et al., Phys.Let. B, 1997, 410, p. 337; M.C. Abreu et al. Phys.Let. B, 1997, 410, p. 327; M. C. Abreu et al. By NA50 Collaboration, Phys.Lett.B, 2001, 499, pp. 85-96*].

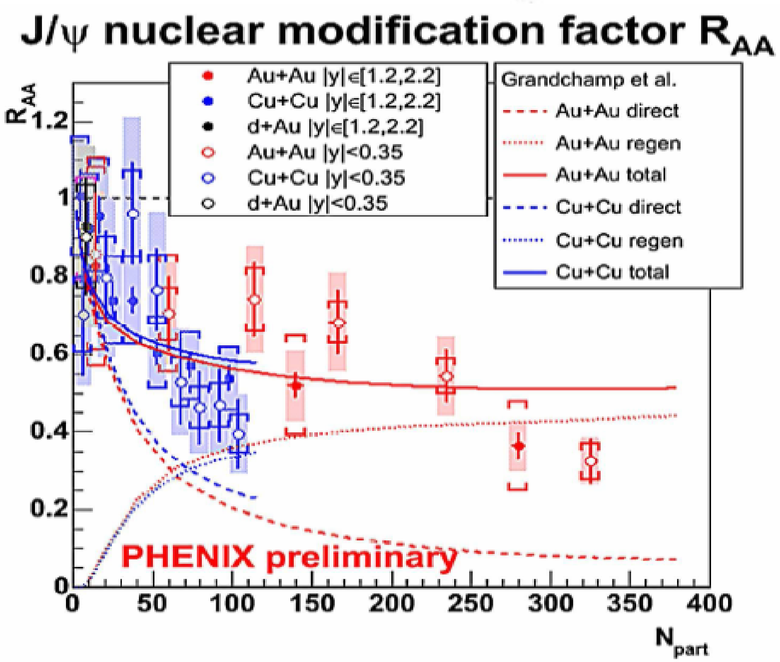
A regime change in the Et range between 40 and 50 GeV both for light and heavy ion collisions and saturation.

Figure 1: Yields of $\bar{p}$, $\bar{\Lambda}$ and $\bar{\Xi}$ as a function of centrality (expressed with the number of participants) in Au-Au collisions normalized to the most peripheral point and to N_{part} (upper frame) or N_{bin} (lower frame).



Recent data obtained by STAR RHIC BNL [*Christelle Roy for the STAR Collaboration POS (HEP2005) 141*] on the behavior of the nuclear modification factors of the strange particles as a function of the centrality in Au+Au- and p+p- collisions at sqrt(sNN) = 200 GeV

Thus we expect to see the new structure in the behavior of the particles yields as a function of the centrality which could connect with the percolation cluster formation[*H. Satz. arXiv: hep-ph/0007069;H. Satz, Nucl. Phys. A642 (1998) 130c.; G. Baym, Physica 96 A (1979) 131*]



Recent results from PHENIX, RHIC on heavy flavor production

[A. A. P. Suaide, Brazilian Journal of Physics, vol. 37, no. 2C, June, 2007, 731-735] shows R_{AA} distributions for Au+Au and Cu+Cu collisions.

At central Au+Au collisions the superession is larger than predicted by normal absorption in cold nuclear matter.

Some Properties of the Central Collisions

The points of regime change appear as some critical phenomena for hadrons-nuclear , nuclear-nuclear interactions and for ultra relativistic ion collisions, in the wide range of energy and almost for all particles (mesons, baryons, strange particles and heavy flavor particles). After point of regime change the saturation is observed. The simple models (such as wounded-nucleon model and the cascade evaporation model) which usually used to describe the high energy hadrons-nuclear and nuclear-nuclear interactions could not explain the results.

Explanation

The dynamics of the phenomena is same for hadrons-nuclear, nuclear-nuclear and heavy ion interactions independent of the energy and mass of the colliding nuclei.

To describe the above mentioned phenomena statistical or percolation mechanism [*Claudia Höhne, GSI Darmstadt. Probing QCD with High Energy Nuclear Collisions, Hirschegg 2005*] are used to explain the experimental results coming from heavy ion physics.

Statistical models give the strong A-dependences than percolation mechanisms. That is why the responsible mechanism for explain the phenomena could be the percolation cluster formation [*Helmut Satzar arXiv:hep-ph/0212046 (2002); Janusz Brzychczyk arXiv:nucl-th/0407008 (2004); C. Pajares. arXiv:hep-ph/0501125 (2005)*].

Big percolation cluster could be formed in the hadrons-nuclear , nuclear-nuclear and heavy ion interactions independent of the colliding energy. But the structure and the maximum values of the reached density and temperature of hadronic matter could be different for different interaction depending on the colliding energy and masses within the cluster.

Paper [*H. Satz. arXiv:hep-ph/0007069 (2000)*] discusses that deconfinement is expected when the density of quarks and gluons become so high then these would strongly overlap; deconfinement is thus related to cluster formation. This is the central topic of percolation theory, and hence a connection between percolation and deconfinement seems very likely [*H.Satz, Nucl.Phys.A642(1998)130c.;G. Baym, Physica 96 A (1979)*]. So we can see that the deconfinement could occur in the percolation cluster.

Author of the paper [*H. Satz. arXiv:hep-ph/0007069 (2000)*] explains the charmonium suppression as a result of deconfinment in cluster.

Experimental observation of the effects connected with formation and decay of the percolation clusters in heavy ion collisions at ultra relativistic energies could provide the information about deconfinement of strongly interacting matter in clusters.

The heavy flavor particles are considered as most sensitive objects to phase transition of strongly interacting matter and to formation of QGP. So it will be very easy to use the heavy flavor particles to reach the goal.

In Ref. [M.K. Suleymanov et al. nucl-exp/0707.1562 (2007)] it was discussed that the study the centrality dependence of heavy flavor particle production . This effect could be used to get the information on the cluster formation and deconfinement in cluster (Prof. E.U.Khan will give more information on this effect in his talk)

In.Ref.*[M.K. Suleymanov et al. nucl-ex/0804.3133]* it was discussed that the investigation of the light nuclei production as a function of the centrality could give the clue on freeze-out state of QGP formation, which could be used as additional information to confirm the percolation cluster formation near the critical point.

There are two types of light nuclei emitted in heavy ion collisions:

first type are light nuclei which produced as a result of nucleus disintegration of the colliding nuclei

second type are light nuclei which are made of protons and neutrons (for example as a result of coalescence mechanism) which were produced in heavy ion interaction

In an experiment we can separate these two types of nuclei from each other using the following ideas:

The yields for first type nuclei have to decrease by some regularity with centrality of collisions.

Formation of the clusters could be a reason of the regime change of the behaviour of light nuclei yields as a function of the centrality in the second type.

Thanks