# DENSE COLD MATTER STUDY WITH SPECIAL TRIGGER AT TWAC, NUCLOTRON, NICA AND FAIR.

## Project Status.

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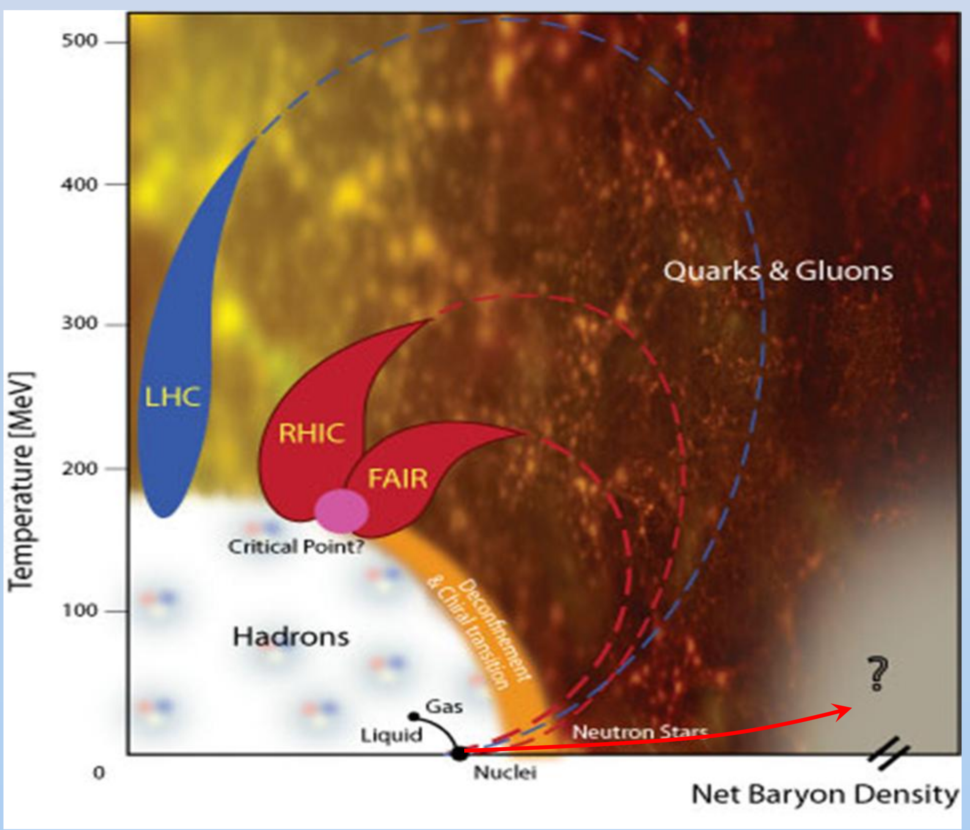
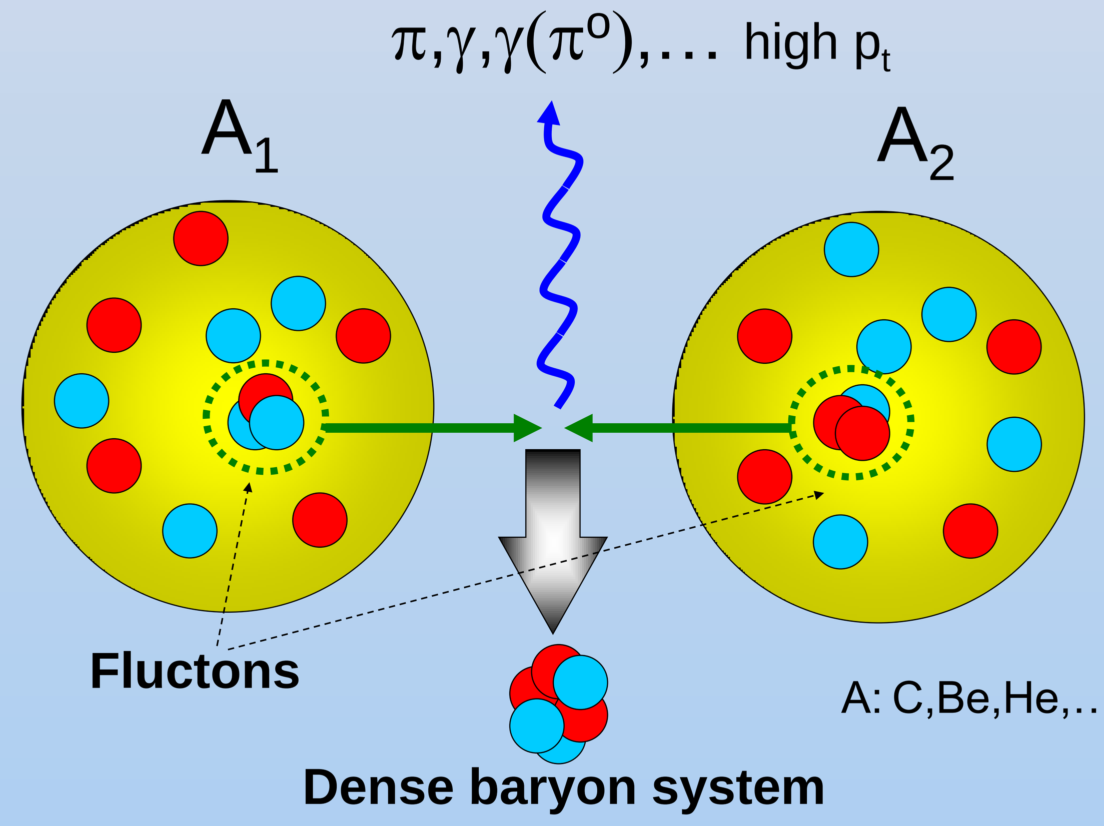
New phase diagram sector at extrimely large baryon density and low temperature is proposed for the laboratory study at TWA(ITEP),Nuclotron-M,MPD-NICA(JINR), CBM@SIS100(FAIR). High pt central rapidity double cumulative trigger for this study is proposed and tested experimentally at ITEP ion accelerator by FLINT collaboration.FLINT experiment is dedicated to the research program of dense cold matter search and study. Experimental data of two runs (2007 and 2010) are presented. Photons spectra where measured in CBe interaction at 3.2GeV/nucleon within angular region 35°–70° (l.s.). It is shown, that the measured photon spectra are indicating the domination of flucton-flucton interaction. Results of two runs are consistent with each other. Proposed measurements programs for future facilities MPD-NICA and CBM-FAIR (SIS100) are discussed.

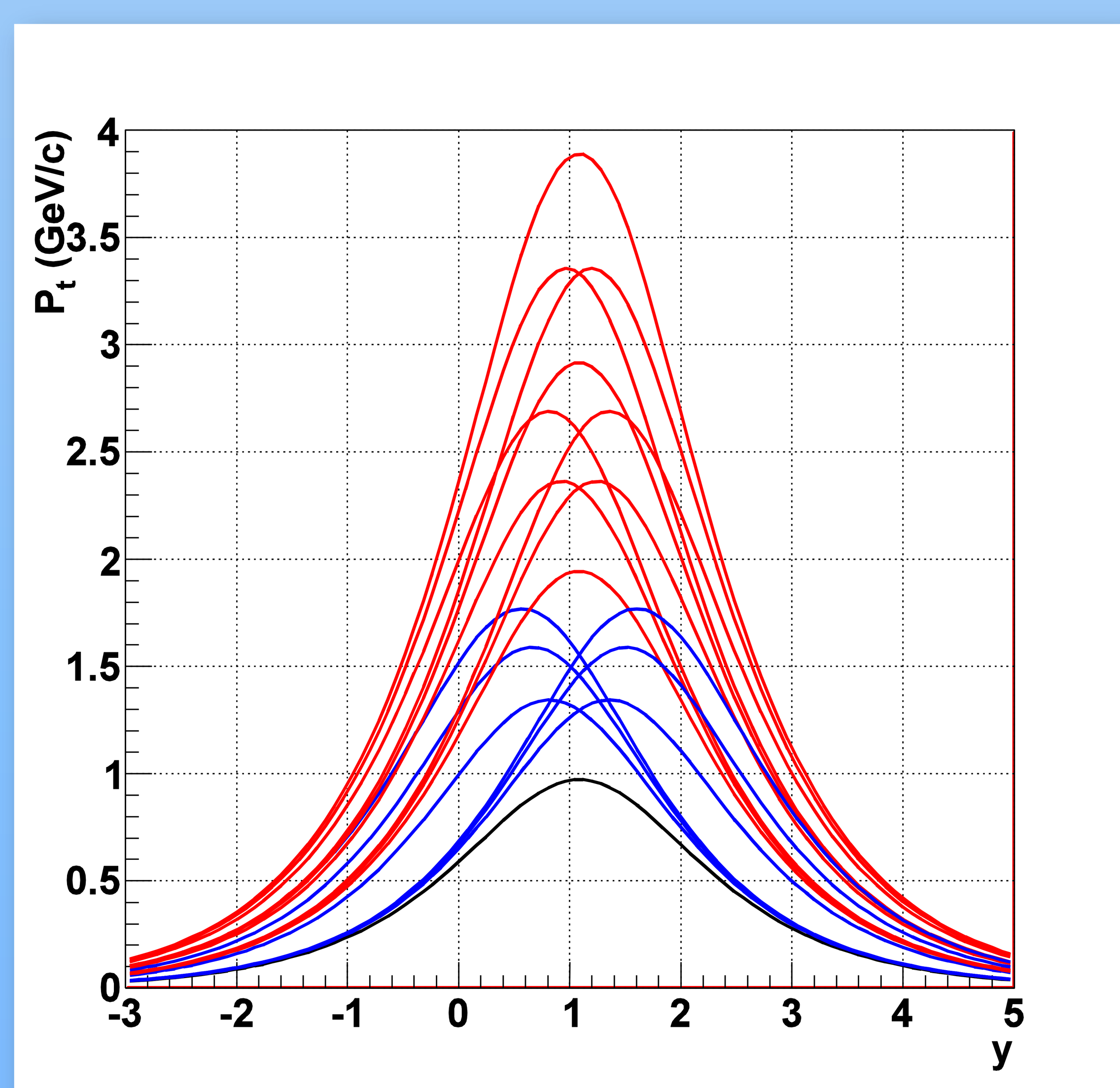



Chromodynamics of media is the subject of research in relativistic nuclear physics field. Different regions of the QCD phase diagram (Fig.1) are an object of interest. One of the main goals for the experiments on heavy ion beams is to find specific signatures in nuclear interactions indicating on the phase transitions presence and study of new form of QCD matter - quark-gluon plasma (QGP). At present the mean experimentalists' efforts are bended on studying the phase diagram at high temperatures and low baryon densities (RHIC, LHC).This corresponds to the theory status ten years ago when the phase diagram consisted only of two regions: hadron phase and QGP. In the late year's advances in theory led to a significant complication of phase diagram. In particular to the appearance of critical point is widely discussed last years. Discovery of critical point at intermediate temperatures and densities is considered as one of the most important goals of FAIR and NICA projects. New phenomena are also predicted at high densities and low temperatures. In this phase space domain first order phase transition and existence of new phenomena like color superconductivity is expected. Low temperatures and extreme densities are probably realized in Nature within neutron stars. This region is hardly to be achieved in laboratory conditions by using standard experimental tools for moving on phase diagram like changing of the initial energy and masses of colliding nuclei, or selecting the impact parameters. Such tools don't provide possibility to study the whole phase diagram but specifie s some rather small area T±dT vs (ρ±dρ).

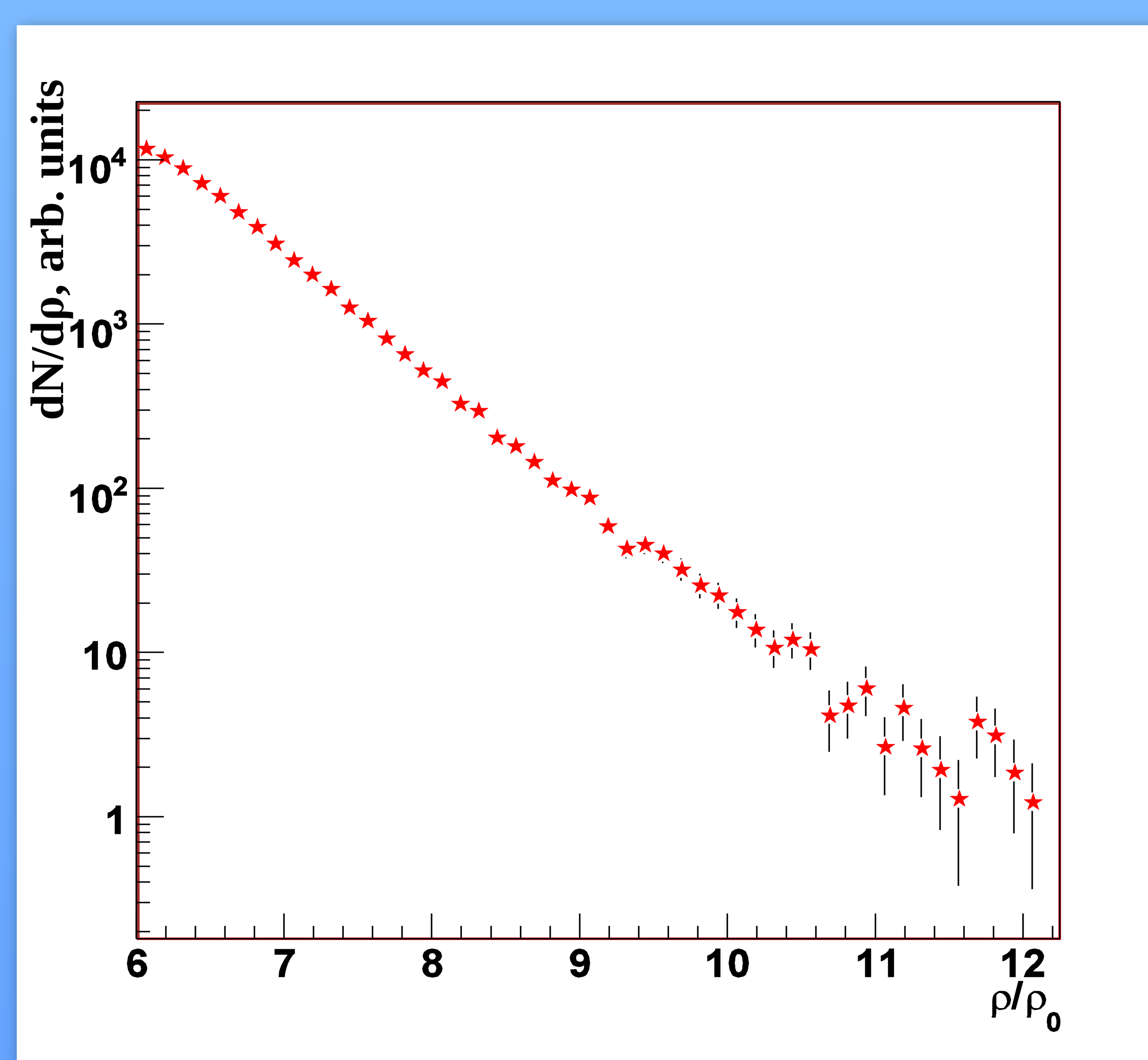


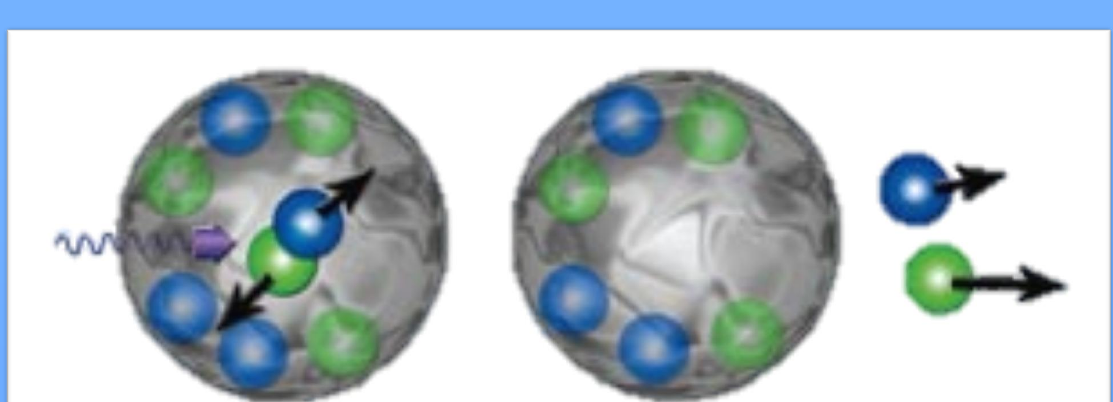

Cumulative effect which has been discovered in 1970's [1] are considered in terms of local fluctuations of nuclear matter from the very bigining. Some properties of cumulative processes, such as strangeness enhancement, are similar to that expected for QGP. However interconnection of cumulative processes and QGP seems to be doubtful because of next arguments. Firstly, if high densities could be realized in cumulative processes, then only in short-lived fluctuations (named by D.I.Blohintsev "fluctons" [2]). Secondly, particles in such fluctuations must be highly virtual and have large relative momentum. Thirdly, these are local few-nucleon fluctuations and it is inconsistently to consider it like a media (although existence of plasma droplets was already discussed, see for example [3]). Recognizing significance of these objections, we will confine ourselves to a following remark. By overcoming them we will obtain an effective trigger for extreme dense nuclear matter. Indeed if we could select (e.g. kinematically) a process where ~ 10 nucleons being in volume of one nucleon, then the density of such formation would be tens times higher the standard nuclear density (~1/6).

We propose to make event selection (trigger) with a photon (pion,kaon) at midrapidity and maximal transverse momentum by colliding light nuclei (from Helium to Carbon, see Fig.2) Due to kinematical restrictions such criterion selects mainly flucton-flucton (FF) interaction (see kinematical boundaries for different processes-Fig.3). We should stress that production of cumulative particle is neither necessary nor sufficient condition for selection of dense baryon system. However we expect an that such selection procedure would increase signal (dense cold matter production) to background (ordinary hadronic matter) ratio for several orders of magnitude. Interaction makes particles participated in both fluctons real (see Fig.4 [4]). The closer the energy of trigger particle to maximal possible for present colliding nuclei, the lower should be internal energy of the secondary baryon system. Therefore the decay of this system will be slowly. This weakens the objection of short lifetime and large relative momenta. And after all at high density much smaller system size is enough to speak about medium because the smallness of free path in comparison with system sizes is the criterium, while the free path decreases with the density increasing. After realization of proposed event selection we suggest to proceed with a bright research program focused on properties of formed in final state system. Theoretically predicted properties of dense baryon system should be checked experimentally. The list of predicted properties will probably become longer in future but it seems already clear nowadays that spin (isospin) system's states, space-time characteristics, exotic particles search such as dibaryons, strangeness enhancement etc. should be studied.

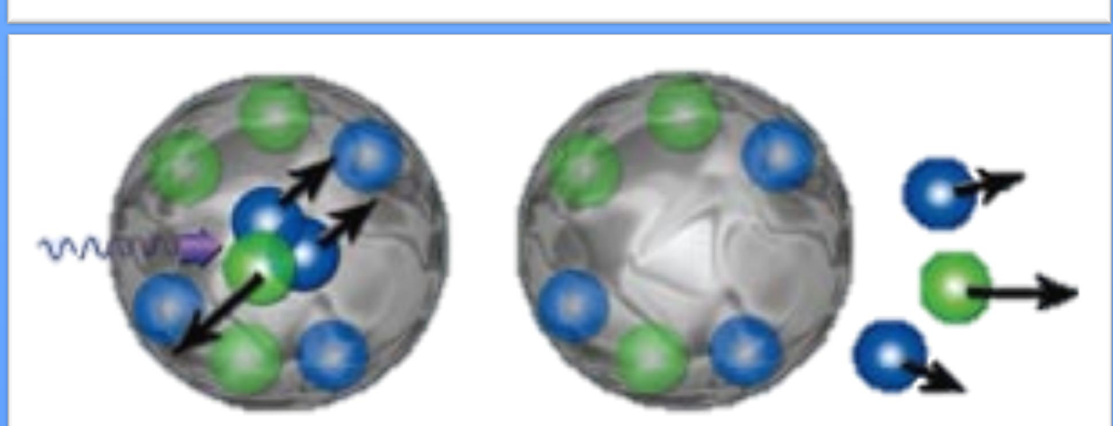



Reality of an effective trigger for the selection of flucton-flucton interaction was experimentally proven in FLINT (FLuctonINTeraction) experiment in ITEP [5]. The trigger realization in FLINT is based on high $p_t$ photon registration in midrapidity range using lead glass electromagnetic calorimeter. Maximal order of cumulativeness $X_{sum} = X_1+X_2$ (where $X_i$ is the minimal number of participating nucleons from colliding nucleus i) achieved at the first stage of the experiment is ~5. This value corresponds to maximum baryon density in the process of the order of 10(see Fig 5). Each additional unit step in $X_{sum}$ value, will result in event rarity increasing 2-3 order of magnitude. The value $X_{sum}$ ~7-8 (maximum baryon density ~ 20) could be accessible experimentally with large acceptance detector at ion-ion interaction rate ~ $10^8$ $sec^{-1}$. The nature of trigger photon (direct photons or photon from unstable particle decay (mostly from $\pi^0$)) is not important for the study because of kinematical limits for photons and pions are approximately the same. Pion, kaon or φ-meson trigger is also possible from physical point of view; possibility of practical realization should be discussed.



*a) Scattering of a virtual photon off a two-nucleon correlation, x > 1.5, before (left) and after (right) absorption of the photon.*



*b) Scattering of a virtual photon off a three-nucleon correlation, x > 2, before (left) and after (right) absorption of the photon.*

1. Baldin A.M. et.al. Sov.J.Nucl.Phys. 1973. V.18. P.79
2. Blokhintsev D.I., Zh. Eksp. Teor. Fiz. 1957. V.33.P. 1295 [Sov. Phys. JETP 1957.V.6.P.995]
3. Seibert D. Phys.Rev.Lett. 1989. V.63. P.136
4. M. Strikman CERN Courier Nov 2, 2005
5. Alekseev I.G. et.al. Physics of Atomic Nuclei. 2008. V.71. P.1848