The Project NICA/MPD at JINR: Status of Design and Construction

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The new project, named NICA/MPD, was proposed at the Joint Institute for Nuclear Research in 2006. It includes the Nuclotron-based Ion Collider fAcility (NICA) and the multi-purpose detector (MPD). The main goal of the project is to start in the coming years experimental study of hot and dense strongly interacting QCD matter. This goal is proposed to be reached by: 1) development of the existing accelerator facility Nuclotron; 2) design and construction of heavy ion collider (NICA) with maximum collision energy of $\sqrt{s}_{NN}$ = 11 GeV (gold) and average luminosity of $10^{27}cm^{-2}s^{-1}$ and 3) design and construction of MPD at intersecting beams. Realization of the project will provide unique conditions for the world community research activity because the highest nuclear (baryonic) density under laboratory conditions can be reached in the NICA energy region. Generation of intense polarized proton and deuteron beams aimed at investigation of polarization phenomena at the Nuclotron M and NICA facilities is foreseen. The maximum c.m. energy of colliding polarized protons is planning to be reached of $\sqrt{s}_{NN}$ = 27 GeV and of $\sqrt{s}_{NN}$ = 12.7 GeV for deuteron collisions. Average luminosity will reach of $10^{30} - 10^{31}cm^{-2}s^{-1}$ in the both modes. The possibility of realization proton - ion and deuteron ion head-on and merging beam collision modes are under consideration also.

1 NICA/MPD Goals and Physics Problems

Theoretical and experimental investigations of the QCD phase diagram are among the most prominent research directions in modern physics. The investigations at NICA are relevant to understanding of the evolution of the Early Universe after Big Bang, formation of neutron stars, and the physics of heavy ion interactions. The new JINR facility will make it possible to study in-medium properties of hadrons and nuclear matter equation of state, including a search for possible signatures of deconfinement and/or chiral symmetry restoration phase transitions and QCD critical endpoint in the region of $\sqrt{s}_{NN}$ =4 -11 GeV (gold) by means of careful scanning in beam energy and centrality of excitation functions.

The first stage measurements includes: 1) Multiplicity and global characteristics of identified hadrons including multi-strange particles; 2) Fluctuations in multiplicity and transverse momenta; 3) Directed and elliptic flows for various hadrons; 4) HBT and particle correlations.

Electromagnetic probes (photons and dileptons) are supposed to be added at the second stage of the project. The beam energy of the NICA is very much lower than the region of the RHIC and the LHC but it sits right on top of the region where the baryon density at the freeze-out is expected to be the highest. In this energy range the system occupies a maximal space-time volume in the mixed quark-hadron phase (the phase of coexistence of hadron and quark-gluon matter similar to the water-vapor coexistence-phase). The net baryon density at LHC energies is predicted to be lower. The energy region of NICA will allow analyzing the highest baryonic density under laboratory conditions (see the phase diagram below). The

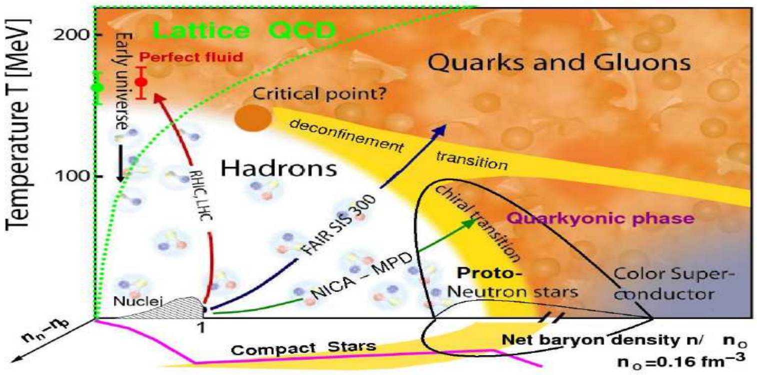

Figure 1: *Phase diagram .*

conditions similar to NICA are expected to be reproduced at FAIR facility in Darmstadt after put the synchrotron SIS300 into operation (in 2015). For more information about Physics at NICA see http://nica.jinr.ru and http://theor.jinr.ru/twiki-cgi/view/NICA/WebHome sites which contain the material of Round Table discussions in 2005-2009 (" NICA White Paper").

2 MPD for Mixed Phase experiments

The experimental set-up of proposed MPD (see its schematic picture below) has to detect the high multiplicity events and perform particle identification in 4 geometry. The MPD consists of a central detector (CD) and two forward spectrometers (FS-A and FS-B) situated along the beam line symmetrically with respect to the centre of MPD. The CD consists of the time projection chamber (TPC) supplemented by the inner tracker (IT) surrounding the interaction region, and two end cap trackers (ECT). The CD aimed to reconstruct and identify both charged and neutral particles in the pseudorapidity region $|\eta| < 2$. The high performance time-of-flight (TOF) system based on RPC allows pion, kaon and proton identification in the broad rapidity range and up to total momentum of 2 GeV/c. The energy loss (dE/dx) measurements in the TPC gas will give an additional capability for particle identification in low momentum region. For the electron/positron and gamma detection and their energy measurement the electromagnetic calorimeter (ECal) is considered. Two ECTs are located on both sides of the TPC. The ECT is designed to provide tracking information for particles traveling at small radii and for which the TPC has poor reconstruction ability. The fast forward detectors (FD), beam-beam counters (BBC) and zero degree calorimeter (ZDC) are used for trigger definition, centrality determination and reconstruction of the position of the interaction point in the ion-ion collision. The FS-A and FS-B cover the pseudorapidity region from 2.0 to 3.0. They are considered as optional.

Here are some basic MPD parameters: 1) we expect that interaction rate of Au+Au events at luminosity of 1027 cm-2s-1 is 10 kHz. (Interaction rate of central events is of 5kHz); 2) The accuracy of vertex reconstruction by means of IT is better then 0.2 mm; 3) The TPC produces

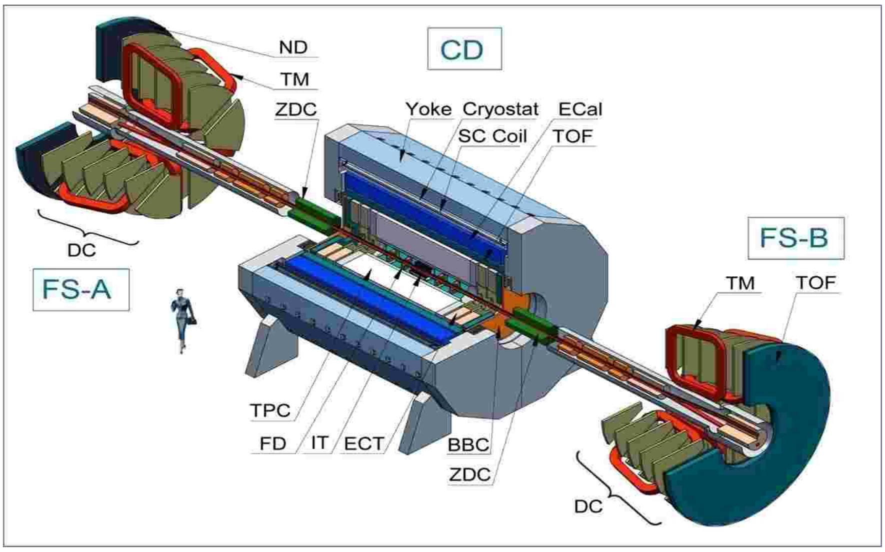

Figure 2: Schematic picture of the MPD detector

50 hits per track and provides the momentum measurement with an accuracy of 1 % in the range of p = 0.2 2 GeV/c. Time of flight system has resolution of 100 ps and provides pion and kaon separation with probability less than 5 % for p< 2 GeV/c.

2.1 NICA General Layout

Construction of the new facility is based on the existing buildings and infrastructure of the synchrophasotron/Nuclotron of the JINR Veksler-Baldin Laboratory of High Energy Physics. Therefore, the total collider ring length is limited to 0.8 of the Nuclotron orbit length and is approximately equal to 202 m. There are two long and two intermediate straights of 34 m and 17 m each respectively in the ring. Four magnetic arcs FODO structure have dense enough magnetic structure. In order to have the collider magnetic rigidity of 45 Tm the bending magnets field has to be increased up to 4 T or higher. The collider option based on 2 T Nuclotron-type dipoles is under consideration also nevertheless, the ring perimeter should be taken not less then 350 m in this case that exclude any possibilities to install it within the existing building. The accelerator chain includes: heavy ion source RFQ injector linac booster ring Nuclotron Superconducting collider rings. The collider NICA will have two interaction points. The MPD, aimed for studies of hot and dense strongly interacting matter and search for possible manifestation of signs of the mixed phase, and the Spin Physics Detector (SPD). The peak design kinetic energy of Au79+ ions in the collider is 4.5 AGeV. Beam cooling and bunching systems are foreseen. The collider magnetic system is fitted to the existing building. The project design presumes realization of some fixed target experiments. Collider operation with polarized deuteron and light ion beams is foreseen as the second stage of the project development.

3 The Project Milestones

The stages of the NICA/MPD project realization proposed in 2006 were fixed as the following: 2007-2009: - Development of the Nuclotron facility, preparation of Technical Design Report, start prototyping of the MPD and NICA elements; 2008-2011: - Design and Construction of NICA and MPD; 2010-2012: - Assembling; 2013: - Commissioning.