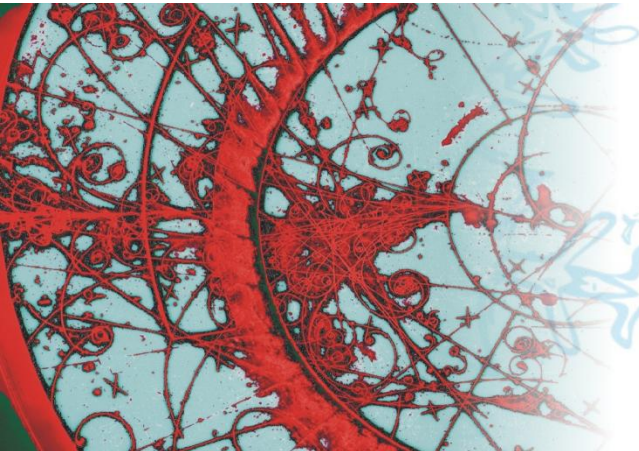
Joint Institute for Nuclear Research
International Intergovernmental Organization

Status of NICA/MPD at JINR

A.S. Sorin

NICA



Dubna International Advanced School on Theoretical Physics / DIAS-TH

X Winter School on Theoretical Physics

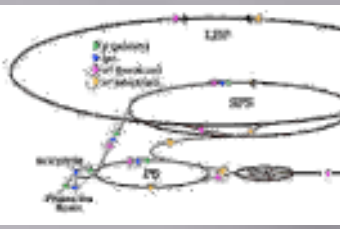
PHYSICS AT THE LARGE HADRON COLLIDER

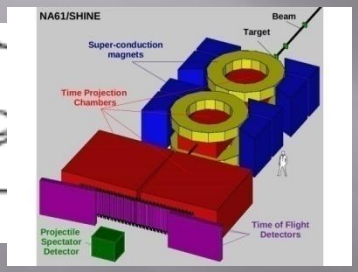
30 January - 6 February, 2012
BLTP JINR, Dubna, Russia

Nuclotron-based Ion Collider fAcility (NICA)

2nd generation HI experiments

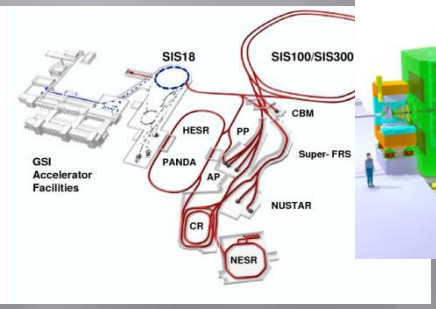
BES STAR/PHENIX@BNL/RHIC

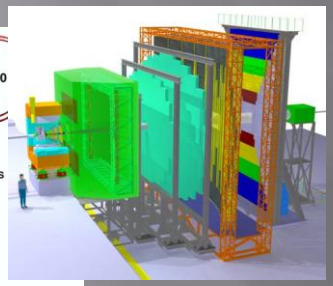




NA61@CERN/SPS

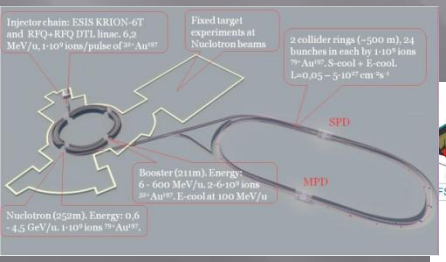
3nd generation HI experiments

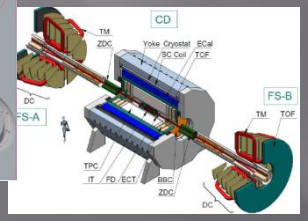




CBM@FAIR/SIS-100/300

Fixed target, E/A=10-40 GeV, highest intensity



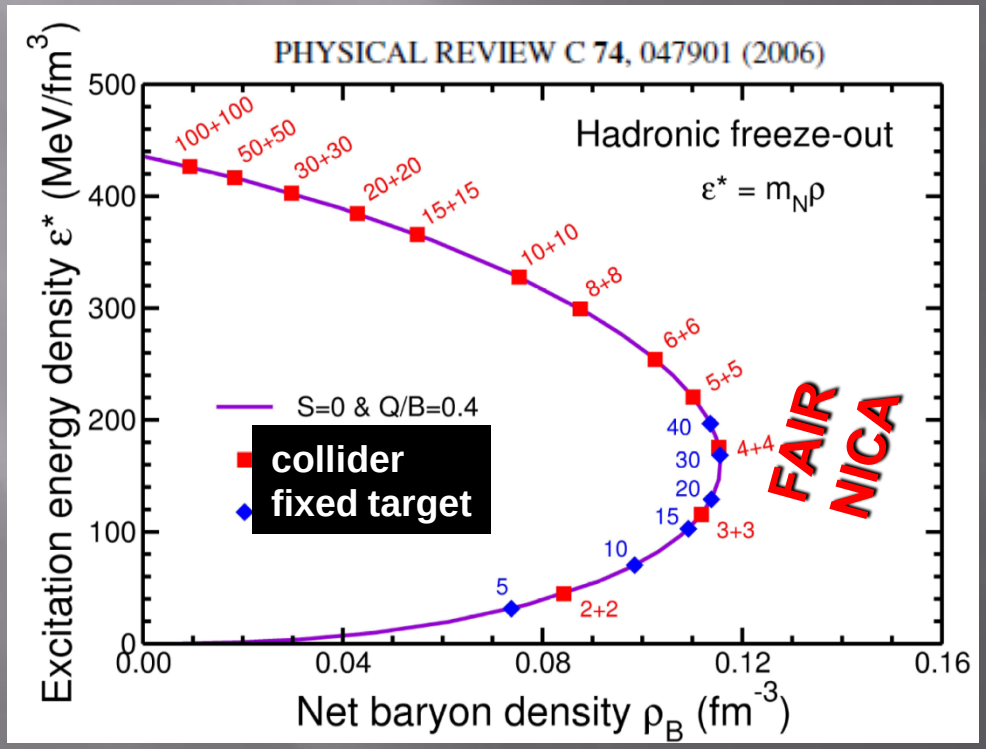


MPD@JINR/NICA.

Collider, $\sqrt{s_{NN}}$ = 4-11 GeV, L~10^{27} $cm^{-2}s^{-1}$ for Au^{79+}

Highest baryon density at Lab

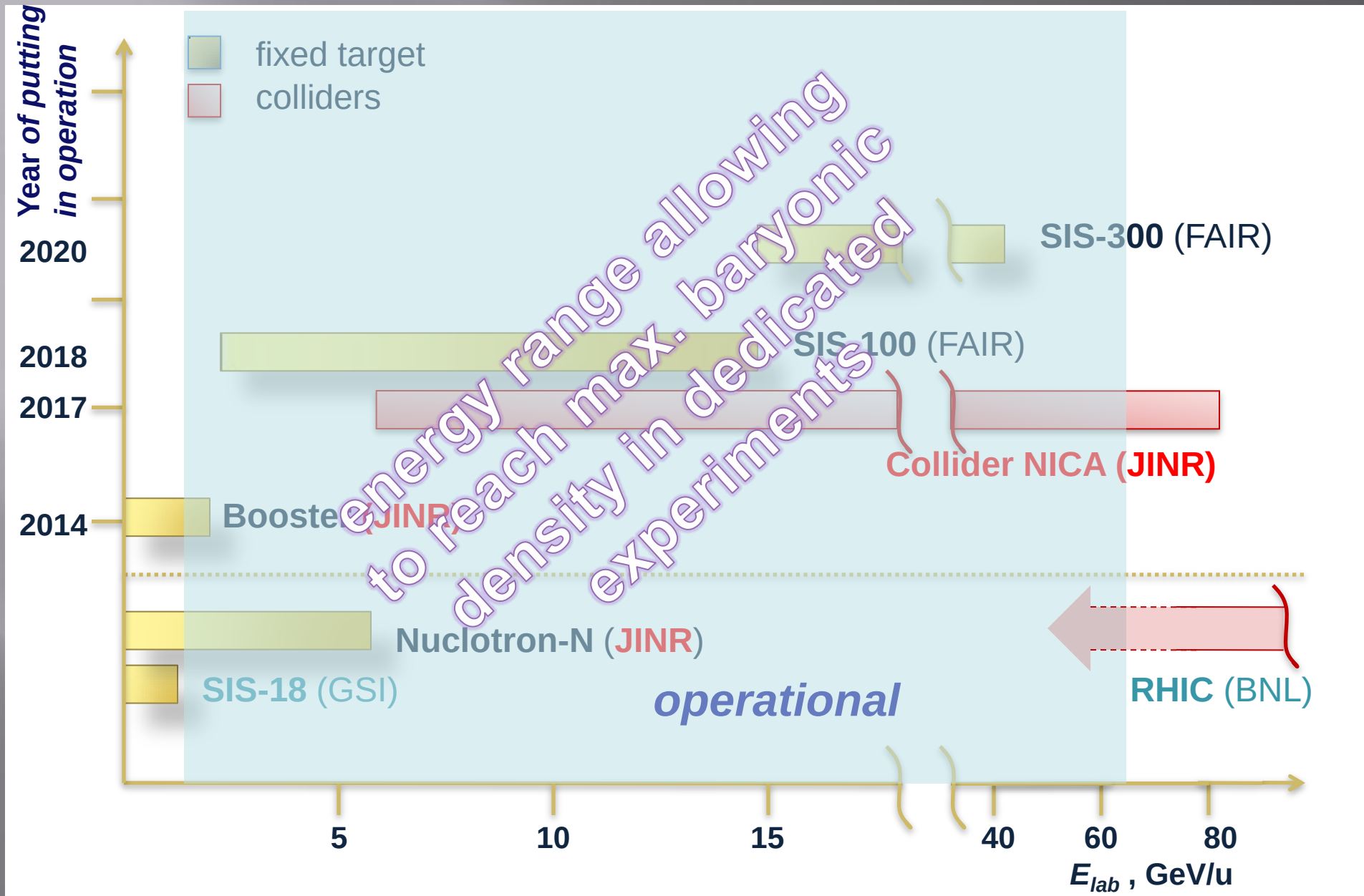
System of maximal net baryon (freeze-out) density is created in A+A collisions at NICA energies → optimum for the compressed nuclear matter exploration



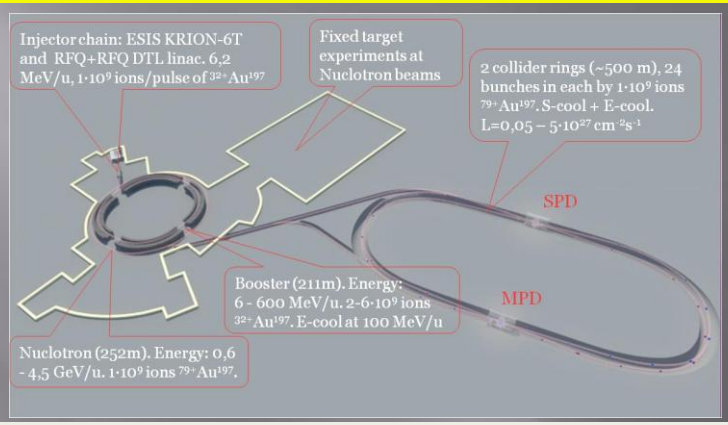
J.Randrup, J.Cleymans, 2006

Energy region covered by the JINR and GSI facilities

(in deutron energy, recalculated for E_{lab})



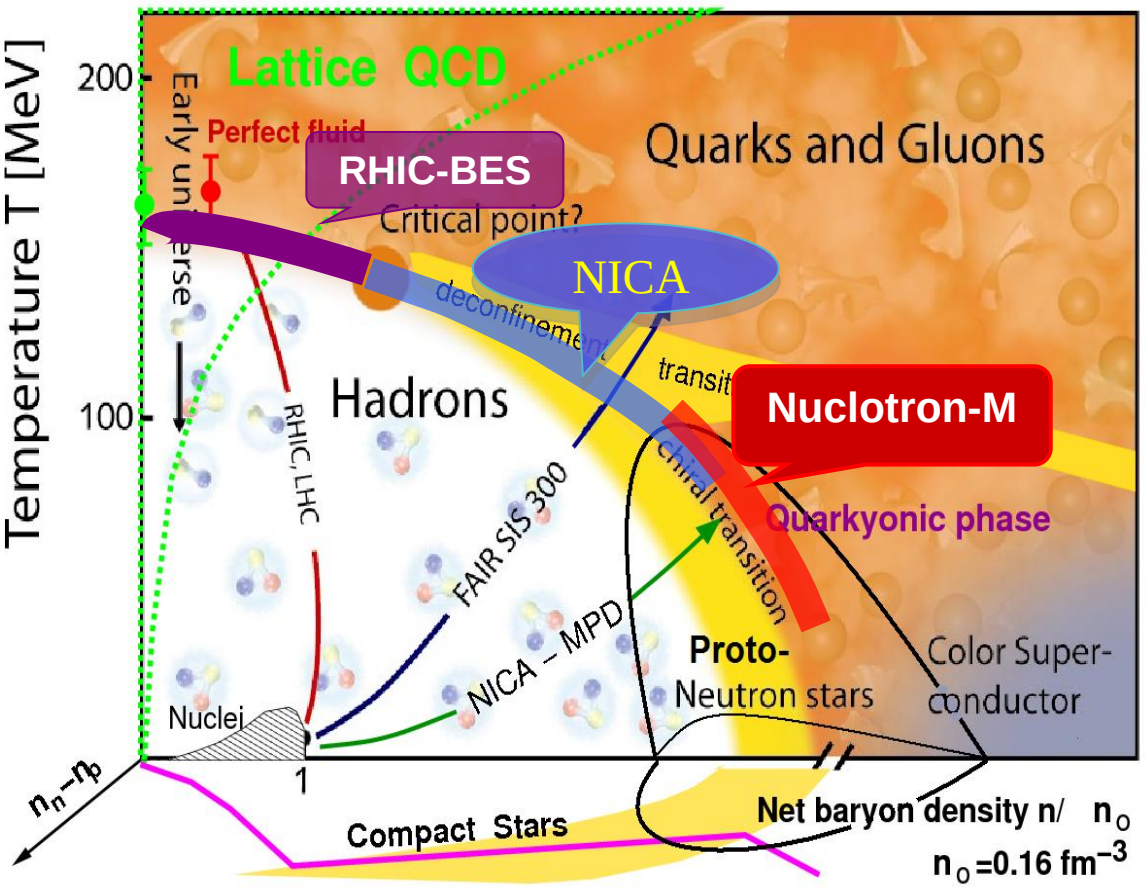
Nuclotron-based Ion Collider fAcility (NICA)



- **Exploration of the QCD phase diagram**
  - *in-medium properties of hadrons & nuclear matter equation of state*
  - *onset of deconfinement & chiral symmetry restoration*
  - *phase transitions, mixed phase & critical phenomena*
  - *local parity violation (P-odd effects)*
- **Spin physics**
  - *to shed light on the origin of spin*
  - *to define the nucleon spin structure*

The planned data taking – 2017

QCD phase diagram: prospects for NICA



Energy Range of NICA

The most intriguing and unexplored region of the QCD phase diagram:

- **Highest net baryon density**
- **Onset of deconfinement phase transition**
- **Discovery potential:**
  - **a) Critical End Point (CEP)**
  - **b) Chiral Symmetry Restoration**
  - **c) Hypothetic Quarkyonic phase**
- **Complementary to the RHIC/BES, NA61/CERN, CBM/FAIR and Nuclotron-M experimental programs**

Comprehensive experimental program requires scan over the QCD phase diagram by varying collision parameters: system size, beam energy and collision centrality

NICA: Nuclotron-based Ion Collider fAcility

- Flagship project at JINR
- Based on the development of the Nuclotron facility
- Optimal usage of the existing infrastructure
- Modern machine which incorporates new technological concepts
- First colliding beams - 2017

NICA advantages:

- Energy range $\sqrt{s_{NN}}$ = 4-11 GeV - highest baryon density
- Available ion species: from p to Au
- Highest luminosity: Au+Au up to 10^{27}

The NICA Project Goals

1) Heavy ion colliding beams 197Au79+ x 197Au79+ at
$\sqrt{s_{NN}}$ = 4 11 GeV (1 4.5 GeV/u ion kinetic energy)
at $L_{average}$= 1E27 cm-2·s-1 (at $\sqrt{s_{NN}}$ = 9 GeV)

2) Polarized beams of protons and deuterons in collider mode:
p↑p↑ $\sqrt{s_{pp}}$ = 12 27 GeV (5 12.6 GeV kinetic energy)
d↑d↑ $\sqrt{s_{NN}}$ = 4 13.8 GeV (2 5.9 GeV/u ion kinetic energy)
$L_{average} \geq$ 1E30 cm-2·s-1 (at $\sqrt{s_{pp}}$ = 27 GeV)

3) The beams of light ions and polarized protons and deuterons for fixed target experiments:

Li ÷ Au = 1 ÷ 4.5 GeV /u ion kinetic energy
p, p↑ = 5 12.6 GeV kinetic energy
d, d↑ = 2 5.9 GeV/u ion kinetic energy

4) Applied research on ion beams at kinetic energy
from 0.5 GeV/u up to 12.6 GeV (p) and 4.5 GeV /u (Au)

The Cosmonaut Yi So-Yeon (South Korea) flies inside the yoke of Synhrophasotron JINR

NICA construction schedule

	2010	2011	2012	2013	2014	2015	2016
ESIS KRION							
LINAC + channel							
Booster + channel							
Nuclotron-M							
Nuclotron-M → NICA							
Channel to collider							
Collider							
Diagnostics							
Power supply							
Control systems							
Cryogenics							
MPD							
Infrastructure							

R&D	Design	Manufactrng	Mount.+commis.	Commis/opr	Operation

MPD: tasks and challenges

- ***bulk observables (hadrons): 4p particle yields (OD, EOS)***
- ***event-by-event fluctuation in hadron productions (CEP)***
- ***femtoscopic correlations involving π, K, p, Λ (OD)***
- ***flows (directed, elliptic,…) for identified hadron species (EOS,OD)***
- ***multistrange hyperon production: yields & spectra (OD, EOS)***
- ***electromagnetic probes (CSR, OD)***
- ***hypernuclei (DM)***
- ***local parity violation (P-odd effects)***

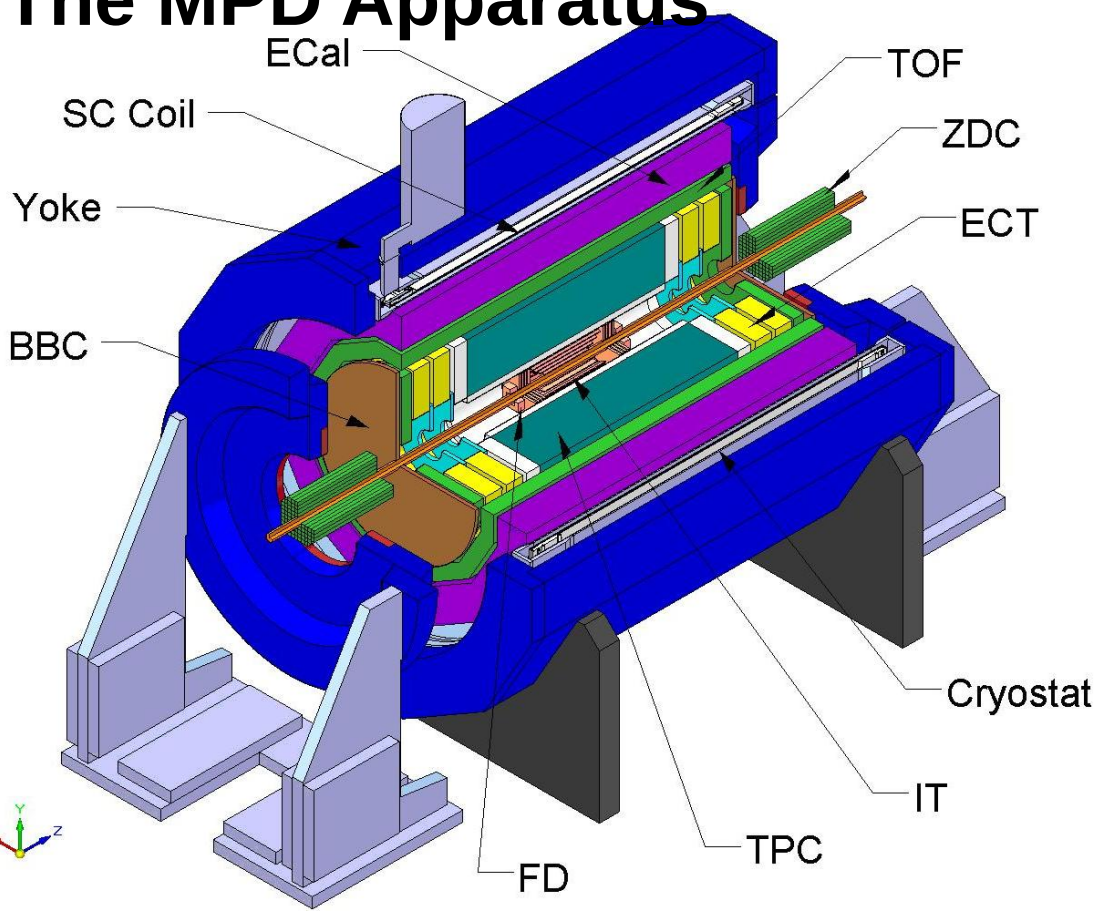
OD – Onset of Deconfinement
CEP – Critical End Point
DM – Dense Matter

CSR – Chiral Symmetry Restoration
EOS – Equation Of State

Challenges:

- **Vast nomenclature of colliding systems – from p+p to Au+Au**
- **simultaneous observation of a variety of phenomena**
- **Small effects over large kinematical range, sensitivity to acceptance constrains (‘correlations & fluctuations’ studies)**
- **Pattern recognition in high track multiplicity environment**

The MPD Apparatus



- **Active volume**
  5 m (length) x 4 m (diameter)
- **Magnet**
  0.5 T superconductor
- **Tracking**
  TPC & straw EndCapTracker & silicon pixels (IT) for vertexing
- **ParticleID**
  hadrons(TPC+TOF), π^0,γ (ECAL), e^+e^-(TPC+TOF+ECAL)
- **Centrality & T0 timing**
  ZDC FD

MPD Advantages:

- **Hermeticity, homogenous acceptance (2π in azimuth), low material budget**
- **Excellent tracking performance and powerful PID**
- **High event rate capability and careful event characterization**

Timetable of MPD construction and commissioning

	Stage/Year	1	2	3	4	5	Total
	Budget profile for MPD ----→	1080	12500	15500	9300	2560	**40940**
1	**Experimental Hall**						
	NICA Hall Construction						
	Electricity,water & infrastructure						
	Crane(construction & certification)						
2	**Superconducting Magnet**						
	Magnet TDR and Tender						
	Call for Tender-Yoke,SC,trim coils						
	Contracts signing						
	Construction of Iron York & SC						
	Transportation						
	Cryogenics for Solenoid						
	Assembling & Commiss. of Solenoid						
	Field measurements						
3	**TPC**						
	TPC Assembling workshop						
	TPC Construction						
	TPC tests						
	TPC installation and Commissioning						
4	**TOF**						
	TOF Assembling area						
	Test area of TOF mRPC						
	TOF Mass Production and test						
	TOF installation & Commissioning						
5	**ECal modules production**						
	ECal Assembling in sectors						
	ECal installation & Commissioning						
6	**ZDC construction and installation**						
7	**Electronics, Network and**						
	DAQ production &implementation						
	Control Room construction						
	Slow Control system implementation						
	Computing for Data taking & network						
8	**Detector Assembling**						
9	**Commissioning and Cosmic Tests**						

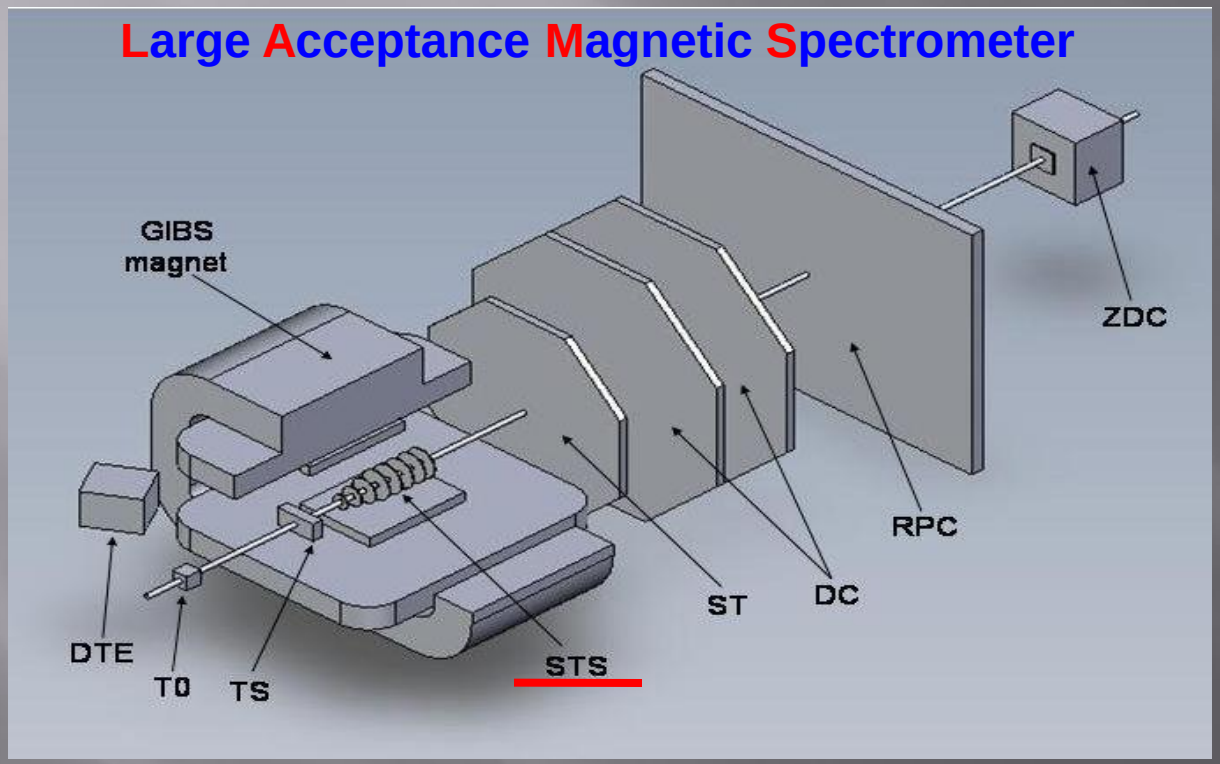
Start up minimum

Strange matter production in heavy ion collisions at the Nuclotron extracted beam: Baryonic Matter at Nuclotron (BM@N)

- Collaboration **GSI-JINR** (preparation of the joint experiment has started)
- The goal of the experiment is the systematic measurements of the observables for multistrange objects (Ξ^-, Ω^-, exotics) in Au-Au collisions in the energy domain of the Nuclotron extracted beam (up to 5 A GeV)

Baryonic Matter at Nuclotron (BM@N)

- measurements of the multi-strange (Ξ, Ω, exotics) & hypernuclei in HI collisions
- close to the threshold production in the region of high sensitivity to the models prediction



GIBS magnet (SP-41)

TS-target station,
T0- start diamond detector,
STS - silicon tracker,
ST- straw tracker,
DC- drift chambers,
RPC- resistive plate chambers,
ZDC- zero degree calorimeter,
DTE – detector of tr. energy.

▣ the detector based on the sub-detectors developed for CBM, MPD & SPD

Preparation of the joint GSI - JINR experiment Baryonic Matter at Nuclotron (**BM@N**) has started. **The planned data taking - 2015**

Time table of the experiment

Working package	2011	2012	2013	2014	2015	2016
Simulations						
Preparation of experimental site						
Installation beam line,						
Installation GIBS magnet						
Installation beam tube, beam monitors						
Construction prototype STS						
Construction SC magnet						
Construction straw tube tracker						
Construction TOF-RPC, T0						
Construction DAQ, slow-control						
Installation drift chambers						
Installation detectors, commissioning						

- **Phase 0 (2011) – The site preparation and simulation**
- **Phase 1 (2012-2014) – The detector construction**
- **Phase 2 (2015-.....) - The data taking**

Editorial board:

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O. Teryaev
I. Tserruya
N. Xu

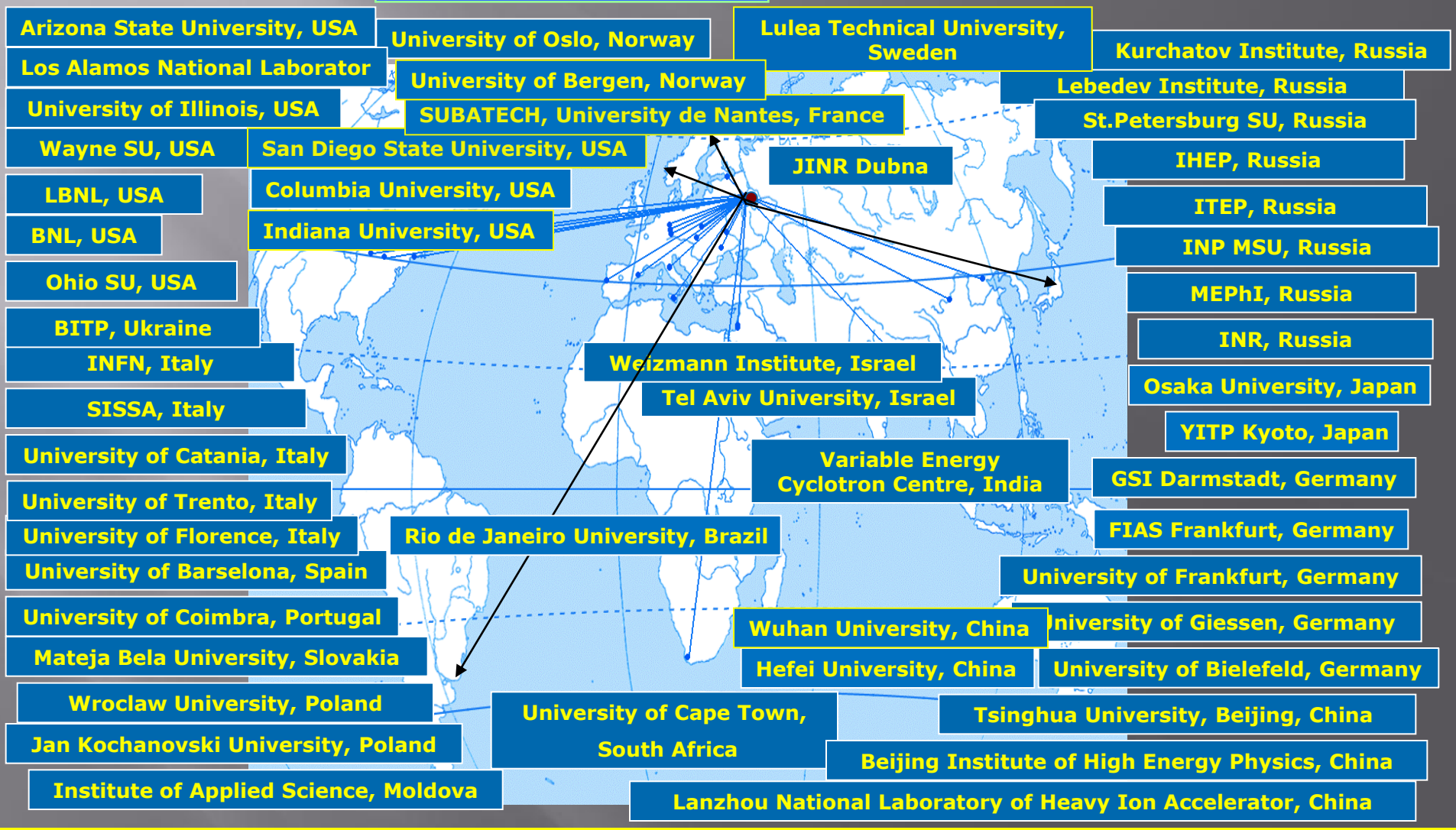
Draft v 6.02
January 20, 2012

SEARCHING for a QCD MIXED PHASE at the
NUCLOTRON-BASED ION COLLIDER FACILITY
(NICA White Paper)

http://theor.jinr.ru/twiki-cgi/view/NICA/WebHome

The NICA White Paper

140 authors *from* **59 scientific centers** *in* **21 Countries (8 JINR members)**



http://theor.jinr.ru/twiki-cgi/view/NICA/WebHome

NICA White Paper - Contents

(75 contributions)

Round Table Discussions on NICA/MPD@JINR

Round Table Discussion I: Searching for the mixed phase of strongly interacting matter at the JINR Nuclotron, *July 7 - 9, 2005*
http://theor.jinr.ru/meetings/2005/roundtable/

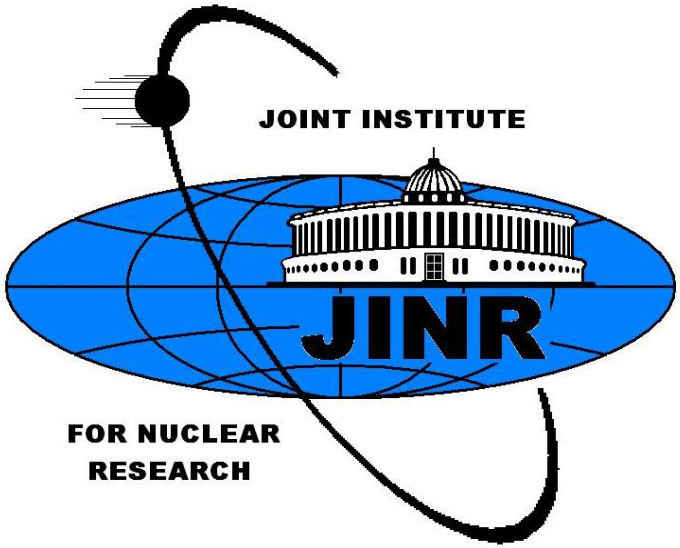
Round Table Discussion II: Searching for the mixed phase of strongly interacting matter at the JINR Nuclotron: Nuclotron facility development JINR, Dubna, October 6 - 7, 2006
http://theor.jinr.ru/meetings/2006/roundtable/

Round Table Discussion III: *Searching for the mixed phase of strongly interacting QCD matter at the NICA: Physics at NICA*
JINR (Dubna), November 5 - 6, 2008,
http://theor.jinr.ru/meetings/2008/roundtable/

Round Table Discussion IV: *Searching for the mixed phase of strongly interacting QCD matter at the NICA: Physics at NICA (White Paper)* JINR (Dubna), September 9 - 12, 2009
http://theor.jinr.ru/meetings/2009/roundtable/

Round Table Discussion V: *Searching for the mixed phase of strongly interacting QCD matter at the NICA: Physics at NICA (White Paper)* JINR (Dubna), August 28, 2010
http://theor.jinr.ru/~cpod/Dubna_2010_program2.htm

Welcome to the collaboration!



Thank you for attention!