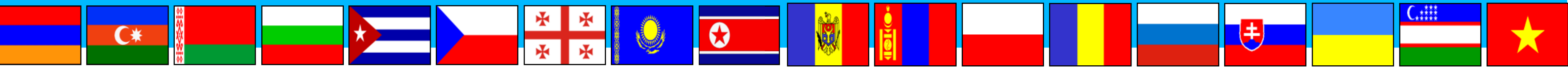
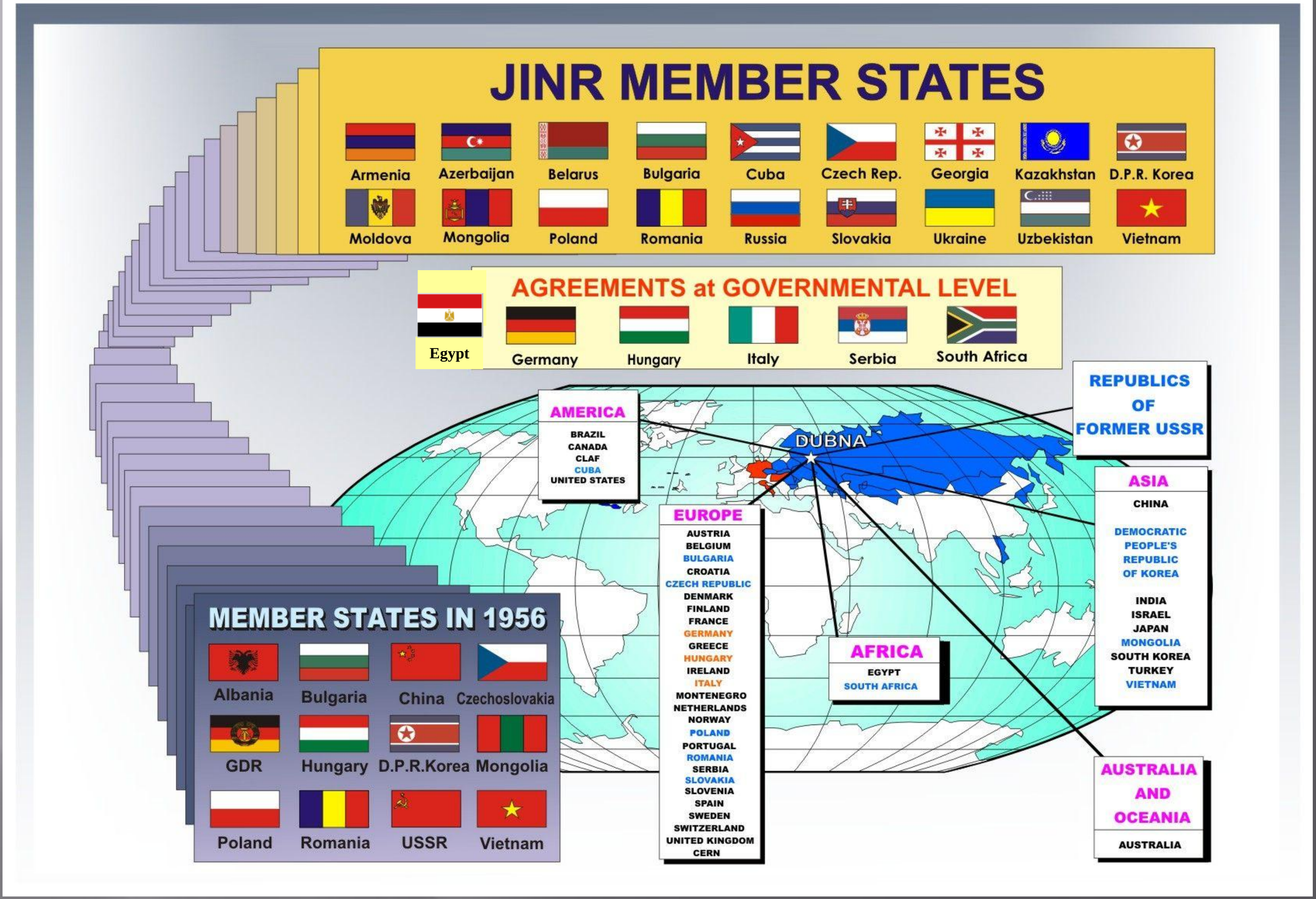
Joint Institute for Nuclear Research
International Intergovernmental Organization



NICA project at JINR

A. Sorin

Dubna International Advanced School of Theoretical Physics
Helmholtz International School
Lattice QCD, Hadron Structure and Hadronic Matter
JINR, Dubna, September 13, 2011



JINR Dubna: International Intergovernmental Organization

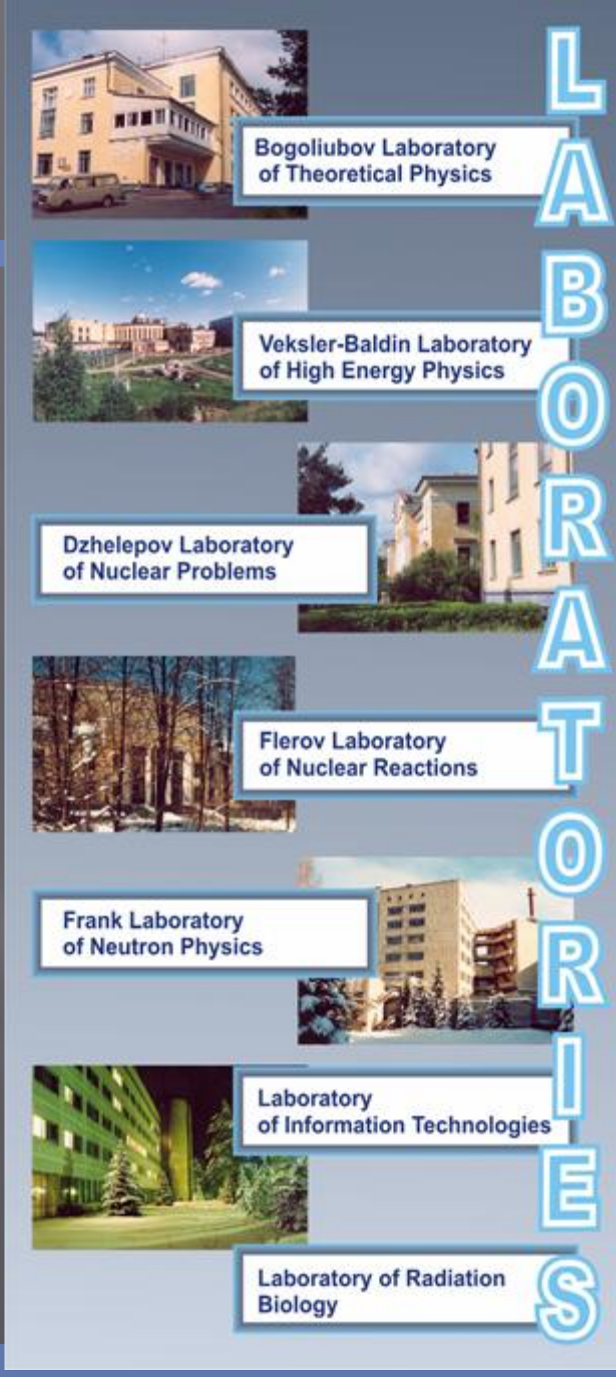
JINR's partners are about 700 institutions located in 60 countries

J I N R

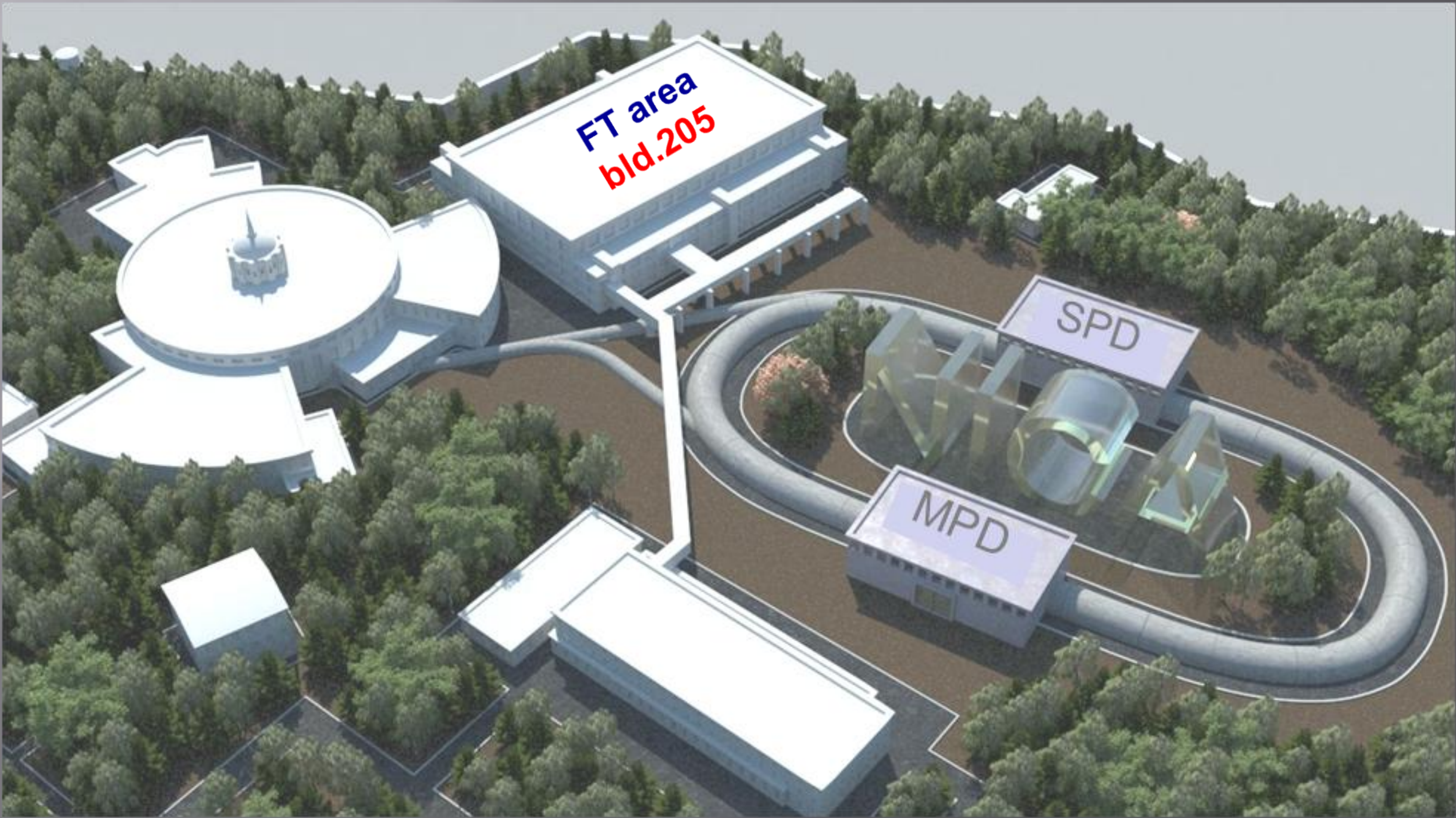
D u b n a

JINR's research niche offered by home facilities

- Heavy-Ion Physics:
  - at high energies (up to 5 GeV/n) (in future $\sqrt{s_{NN}} = 11$ GeV, NICA facility)
  - at low and intermediate energies (5 – 100 MeV/n)
- Condensed Matter Physics using nuclear physics methods



Nuclotron-based Ion Collider fAcility (NICA)

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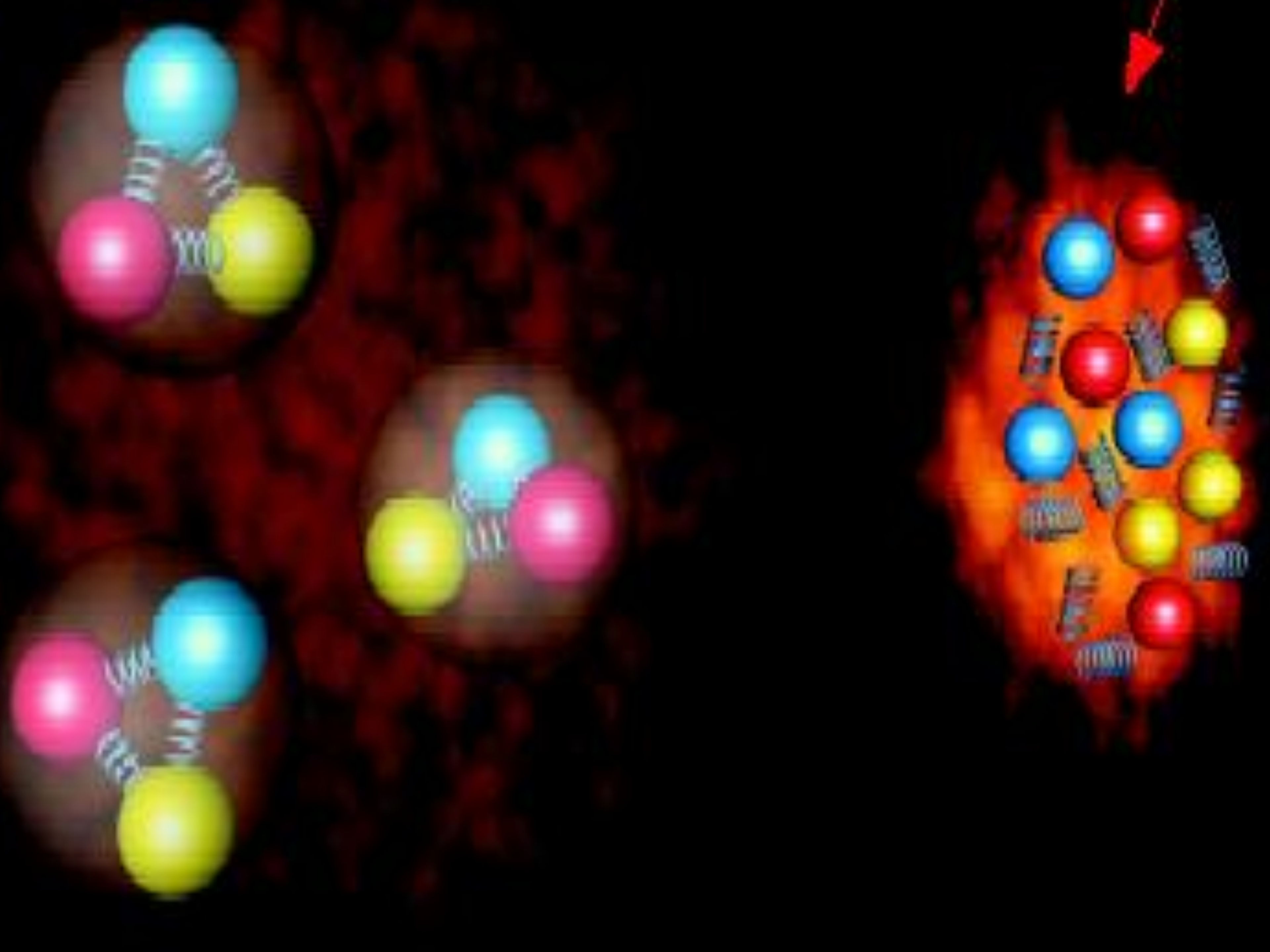
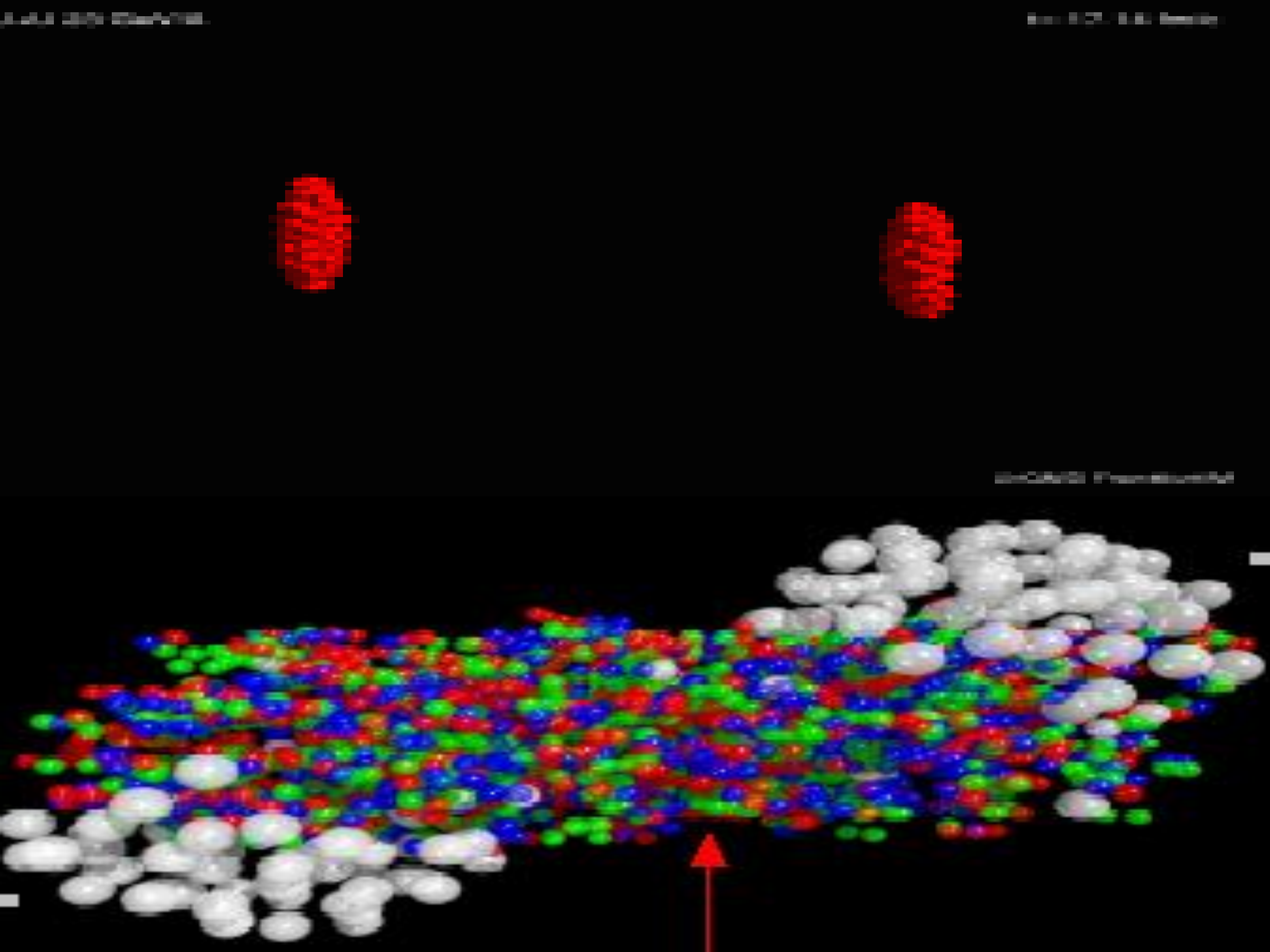
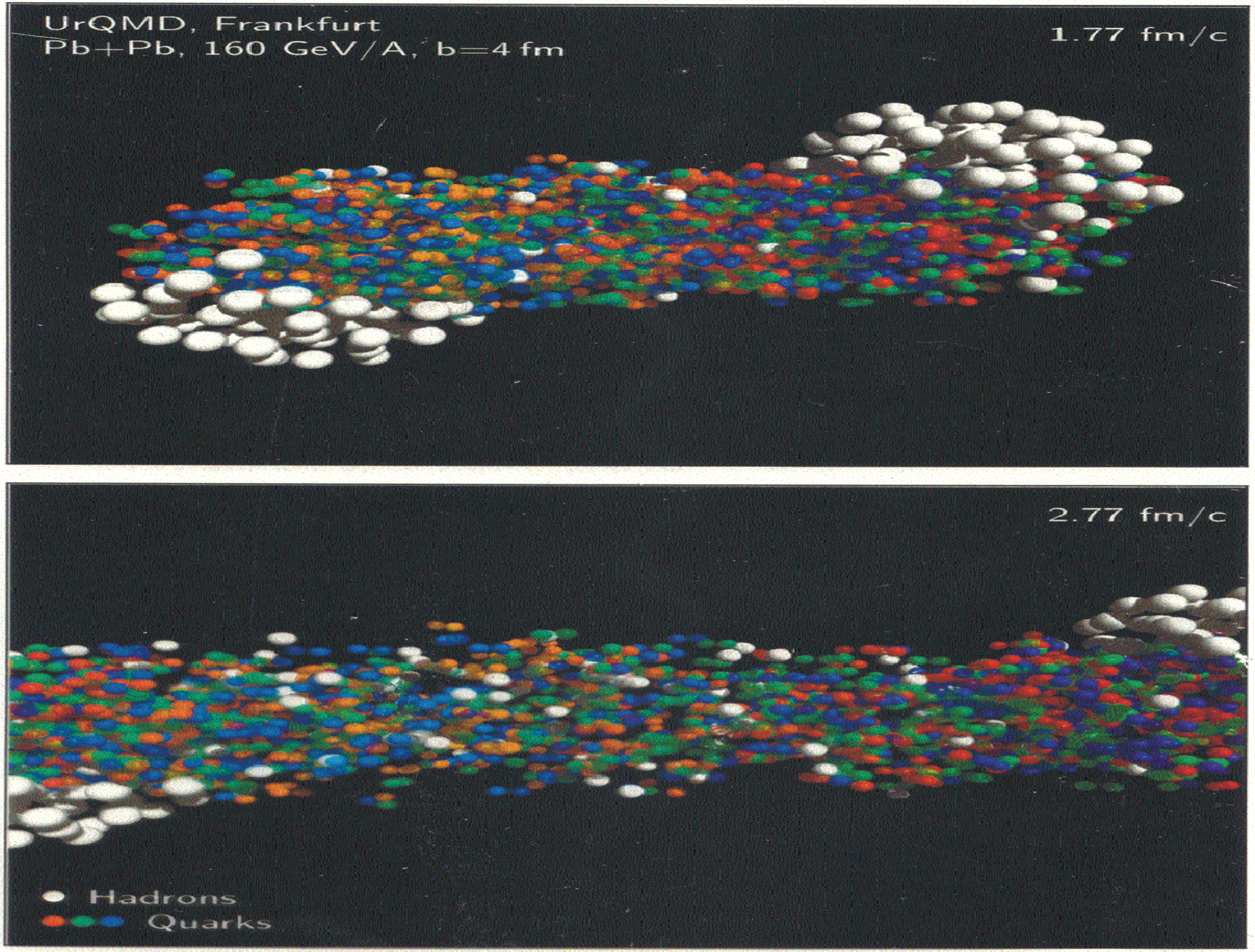
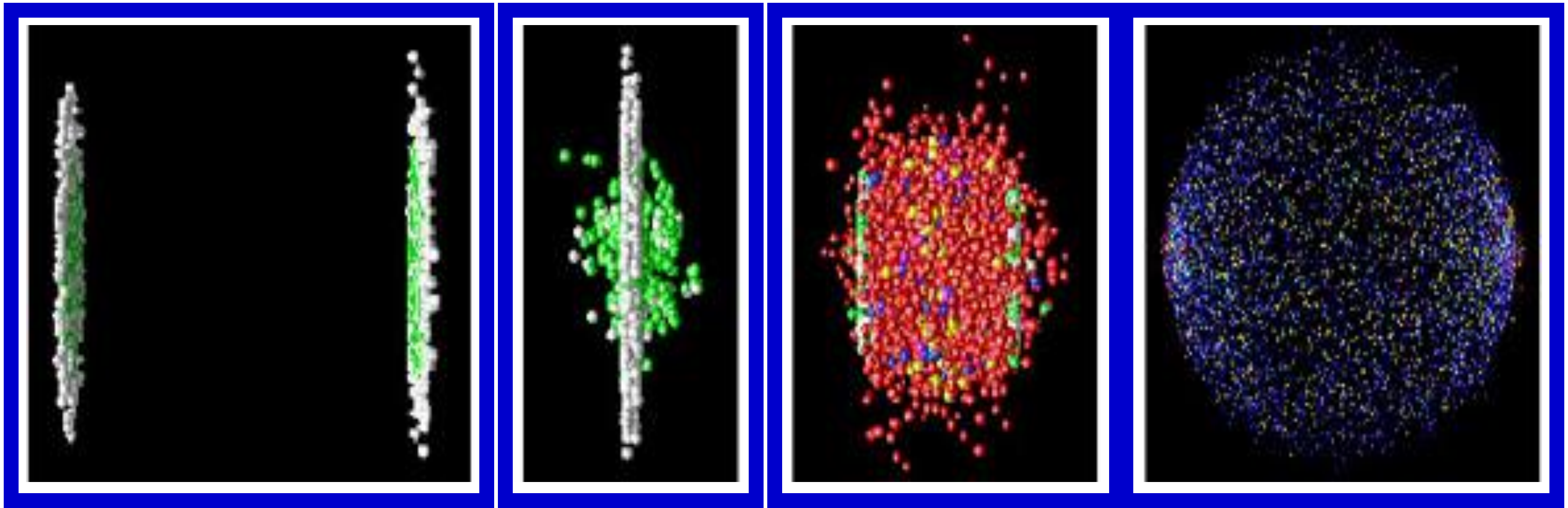





UrQMD, Frankfurt
Pb+Pb, 160 GeV/A, b=4 fm
1.77 fm/c
2.77 fm/c
Hadrons
Quarks

Time line of a relativistic heavy ion collision

1 2 3 4

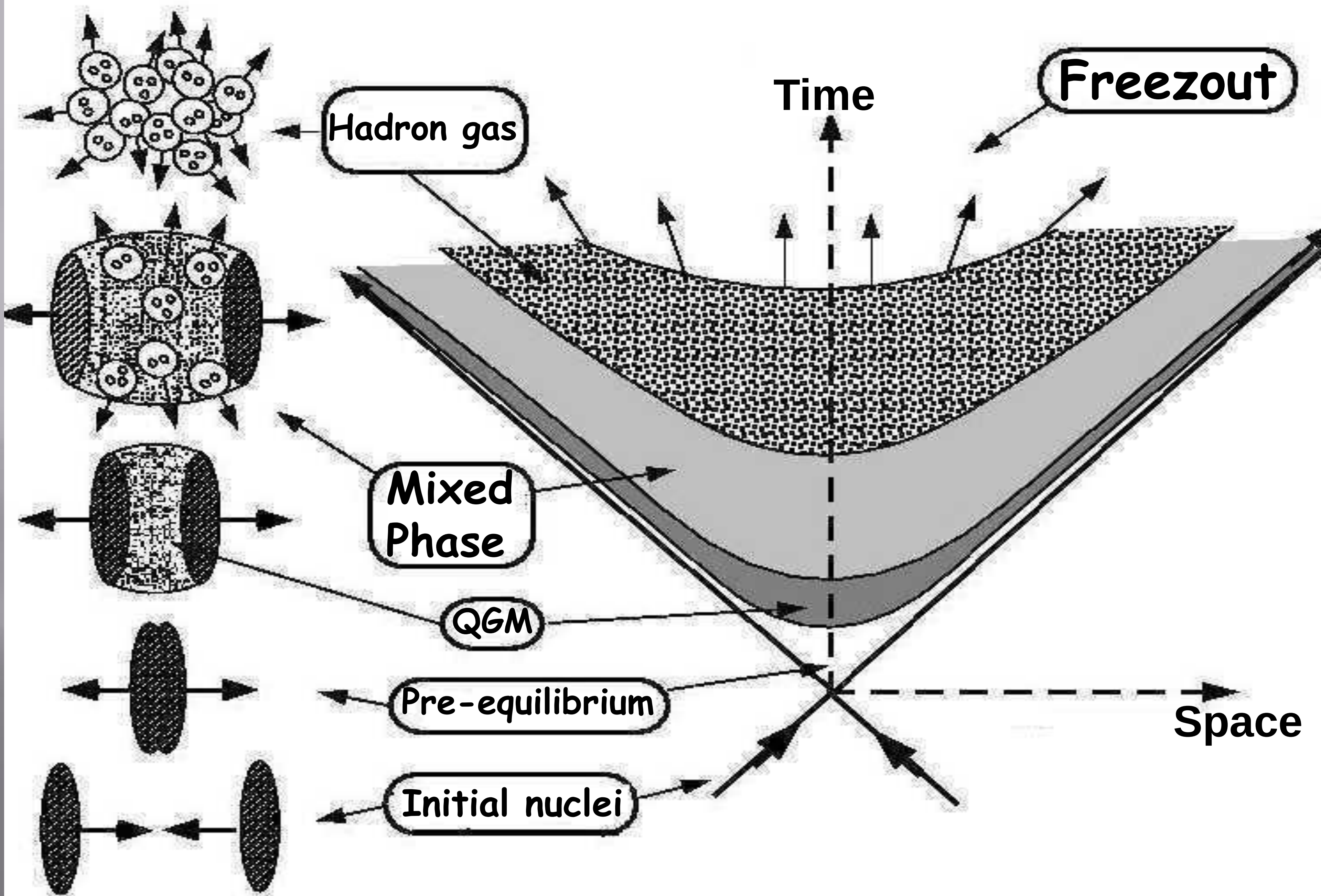


Two thin disk
quarks and gl
approach

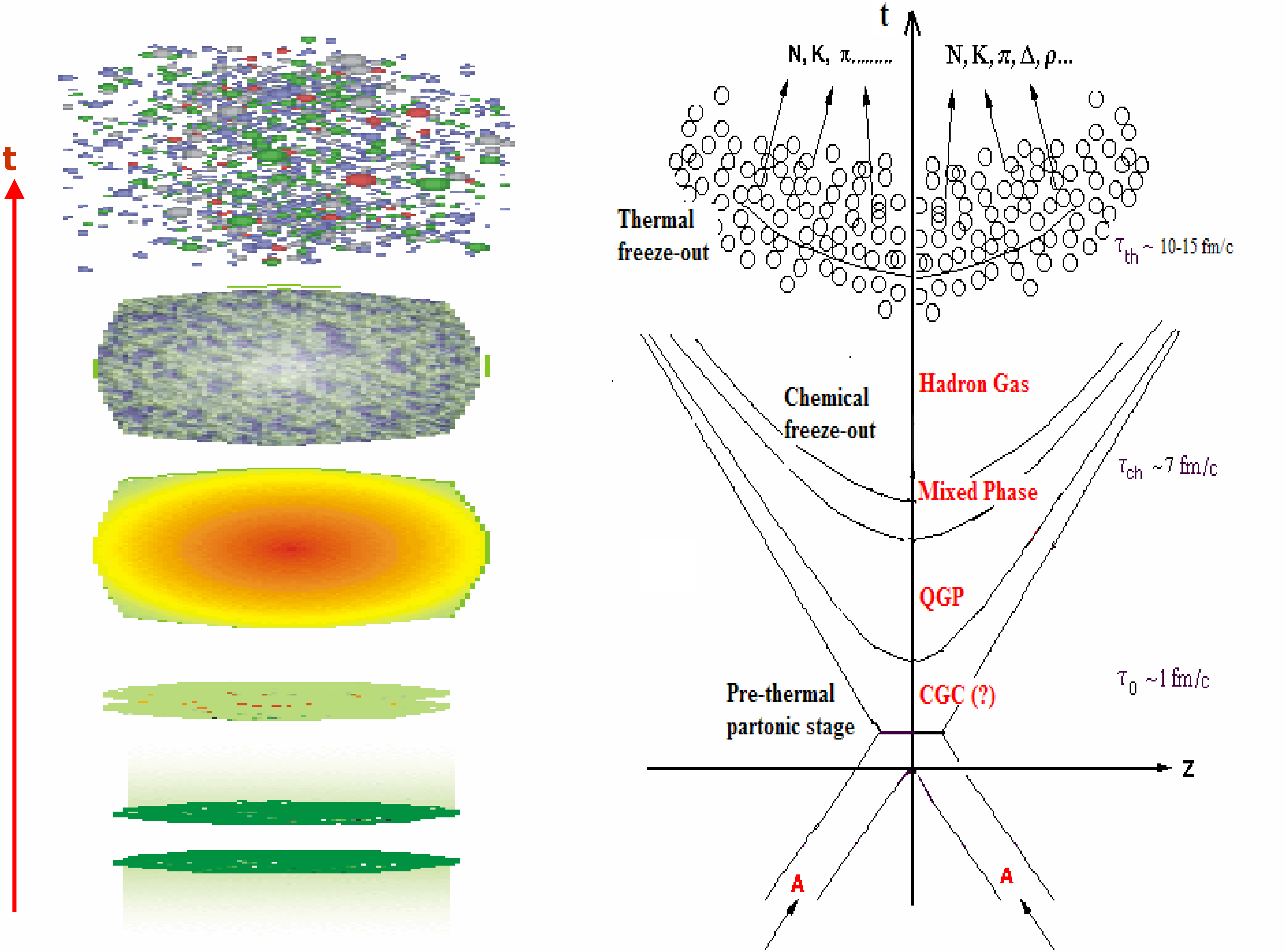
Initial collisi
products of
scattering cr

Dense partonic
medium
The QGP?
The sQGP?
A "perfect liquid"?

Hadron gas phase



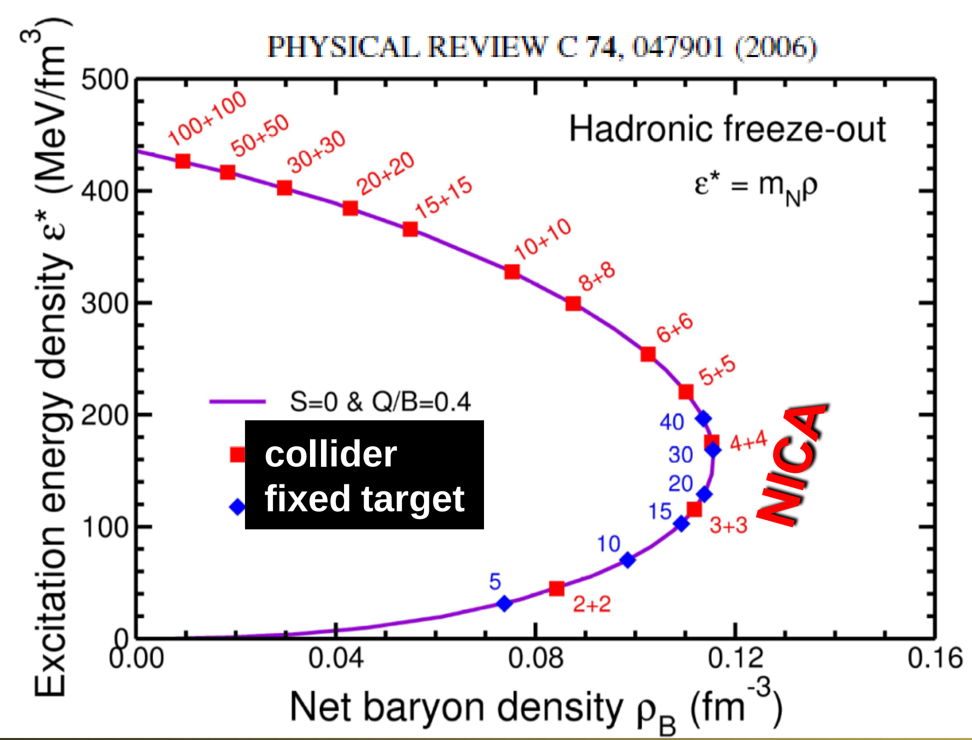
Time
Freezout
Hadron gas
Mixed Phase
QGM
Pre-equilibrium
Space
Initial nuclei



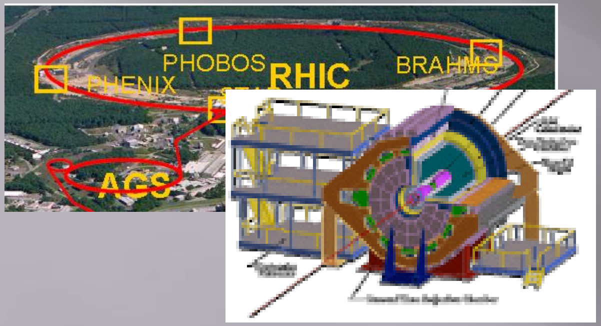
t
t
N, K, π........
N, K, π, Δ, ρ...
Thermal
freeze-out
τth ~ 10-15 fm/c
Hadron Gas
Chemical
freeze-out
τch ~7 fm/c
Mixed Phase
QGP
τ0 ~1 fm/c
CGC (?)
Pre-thermal
partonic stage
z
A
A

NICA domain (baryon density)

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

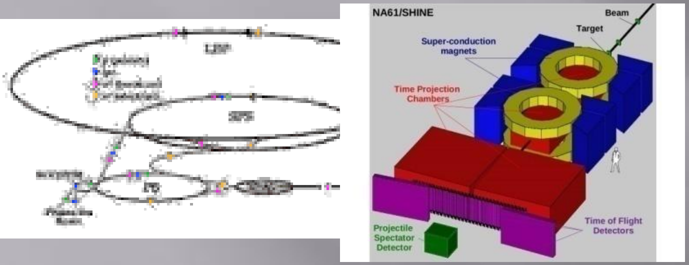


J.Randrup, J.Cleymans, 2006



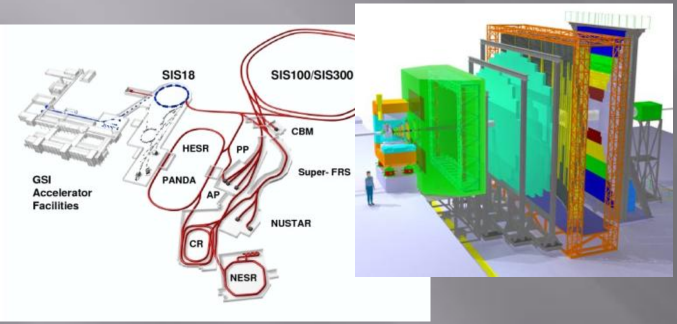
2^{nd} generation HI experiments

STAR/PHENIX @ BNL/RHIC. Originally designed for higher energies ($\sqrt{s_{NN}}$ > 20 GeV), low luminosity for BES program $L<10^{25}$ $cm^{-2}s^{-1}$ for Au^{79+}

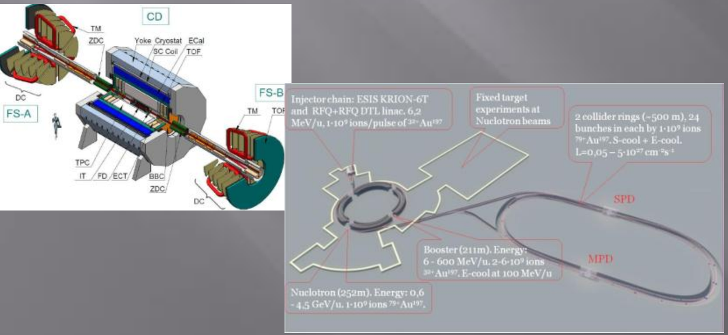


NA61 @ CERN/SPS. Fixed target, non-uniform acceptance, few energies (10,20,30,40,80,160A GeV), poor nomenclature of beam species

3^{nd} generation HI experiments

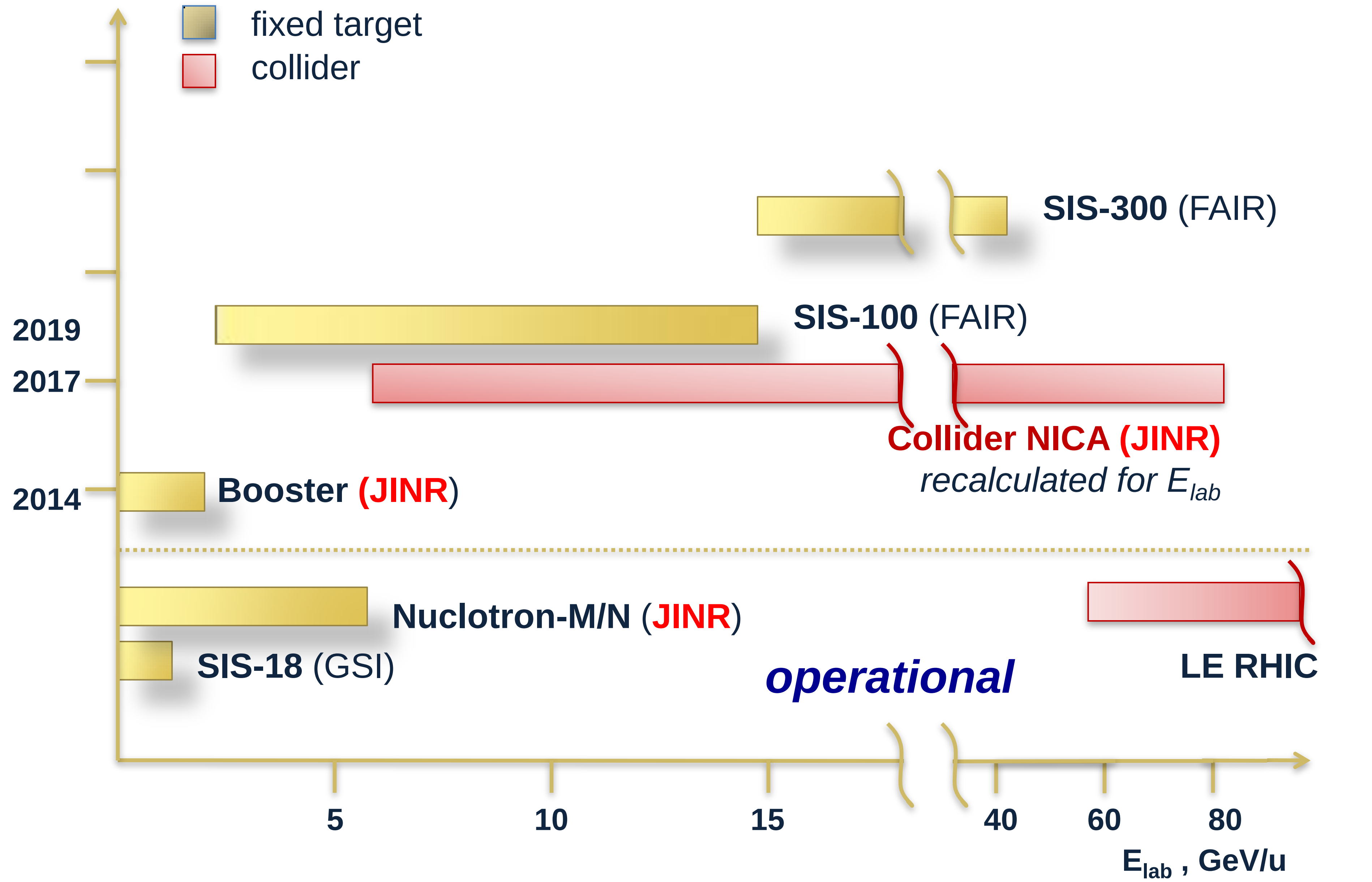


CBM @ FAIR/SIS-100/300
Fixed target, E/A=10-40 GeV, high luminosity

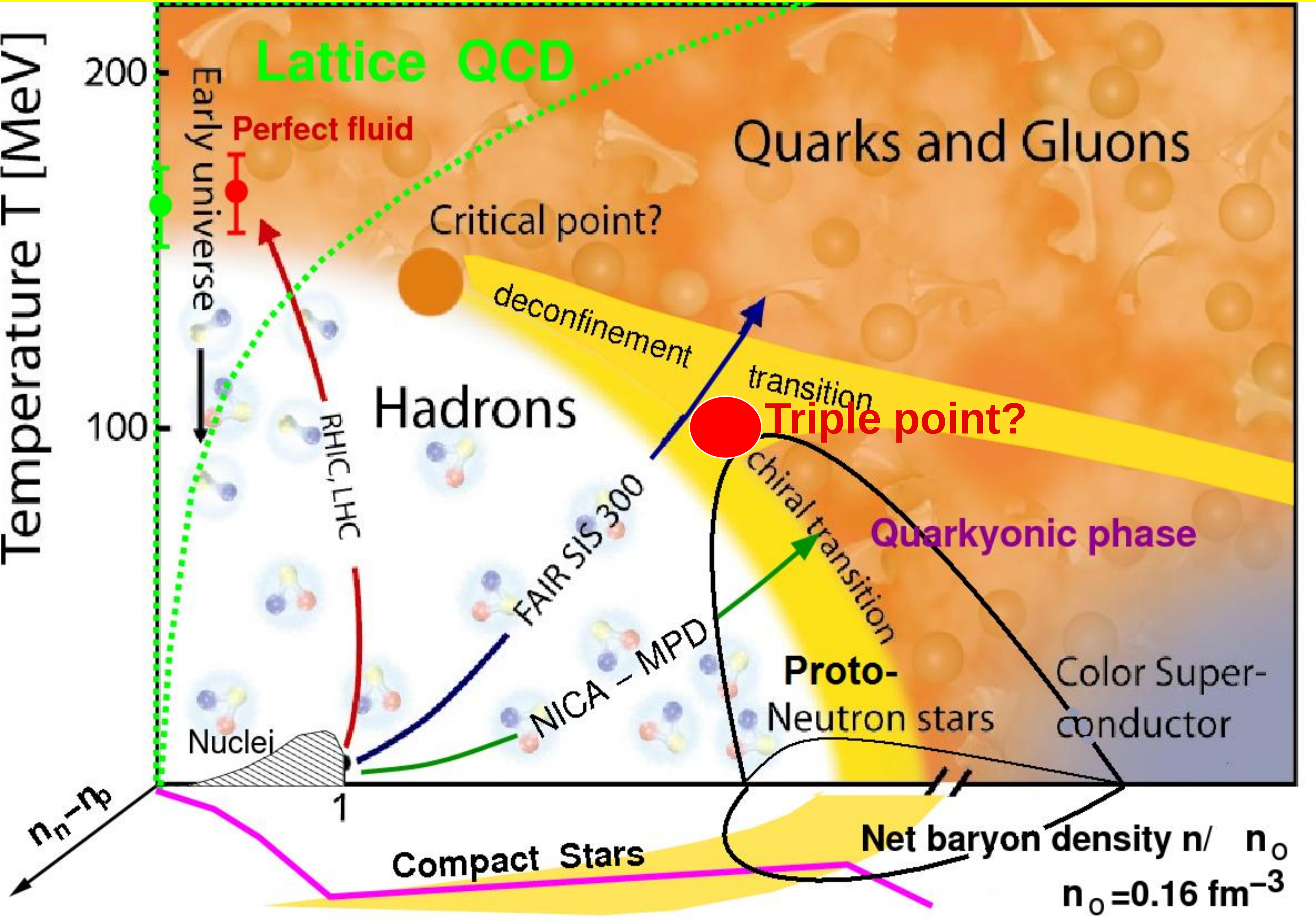


MPD @ JINR/NICA. Collider, small enough energy steps in the range $\sqrt{s_{NN}}$ = 4-11 GeV, a variety of colliding systems, $L \sim 10^{27}$ $cm^{-2}s^{-1}$ for Au^{79+}

energy comparison for deuteron beams



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

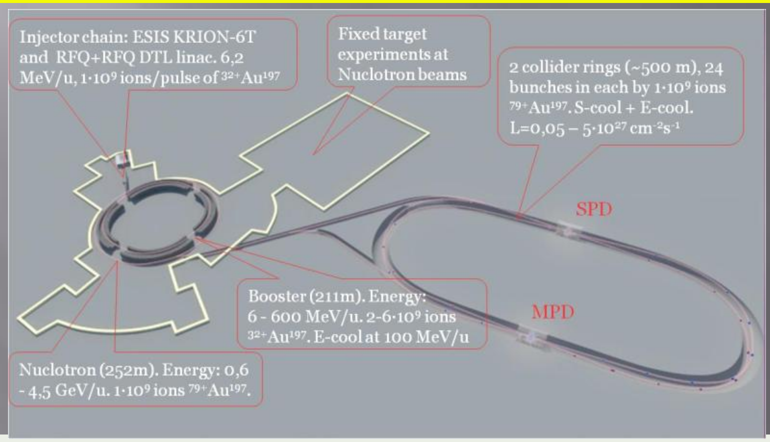


Heavy Ion Collisions (HIC) @ NICA

to study fundamental properties of the theory of strong interactions (QCD) :

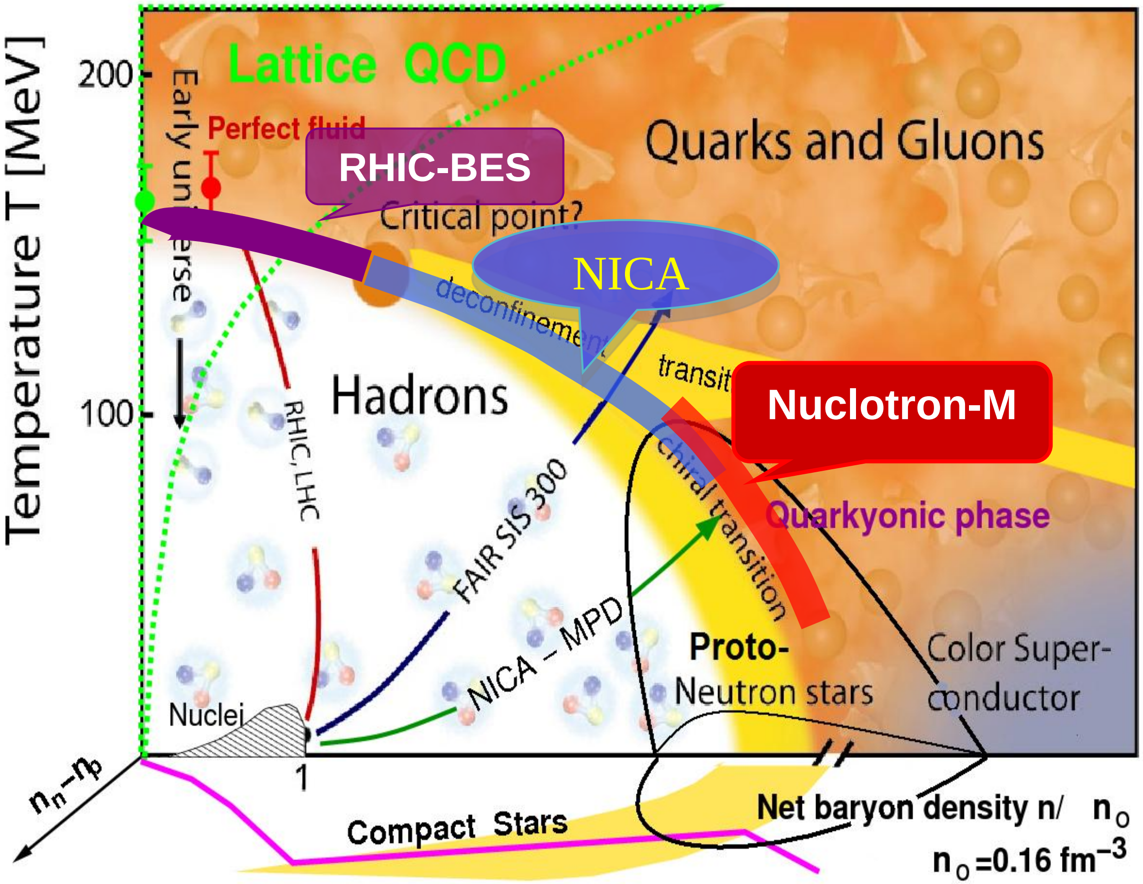
- Modification of the QCD vacuum at high baryon densities, indication of Chiral Symmetry Restoration
- Deconfinement phase transition and properties of the mixed phase
- QCD phase diagram and search for the Critical End Point
- Astrophysics: evolution of the Universe, dense nuclear objects (neutron stars)
- New technologies in accelerators and detectors

Nuclotron-based Ion Collider fAcility (NICA) Goals:



- **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***

QCD phase diagram: prospects for NICA



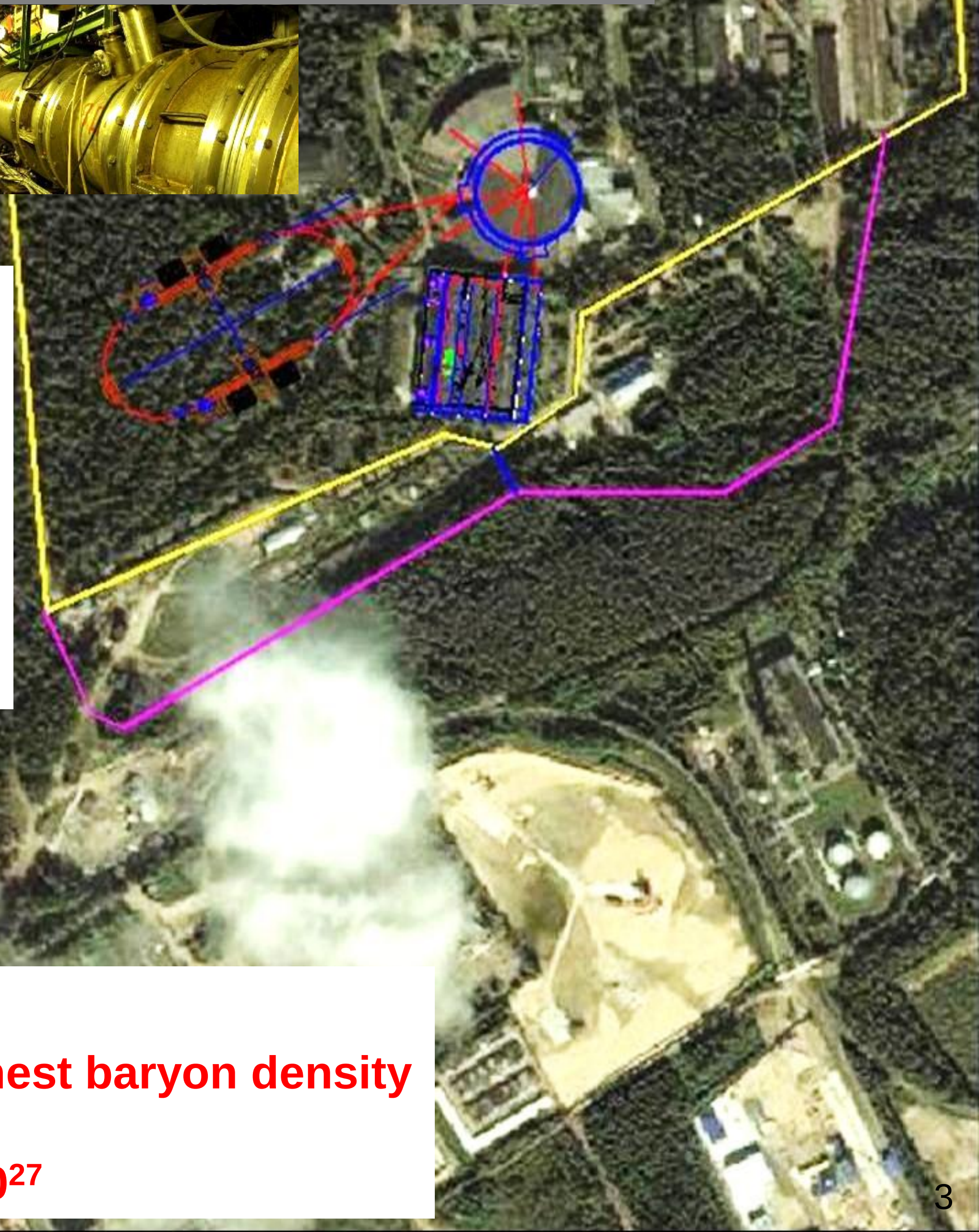
Energy Range of NICA

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

- **Highest net baryon density**
- **Onset of deconfinement phase transition**
- **Strong discovery potential:**
  a) Critical End Point (CEP)
  b) Chiral Symmetry Restoration
  c) Hypothetic Quarkyonic phase
- **Complementary to the RHIC/BES, CERN, 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
Location: JINR, Dubna



- 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 expected in 2016

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 goal of the project

1a) 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)

1b) Light-Heavy ion colliding beams of the same energy range and luminosity

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)

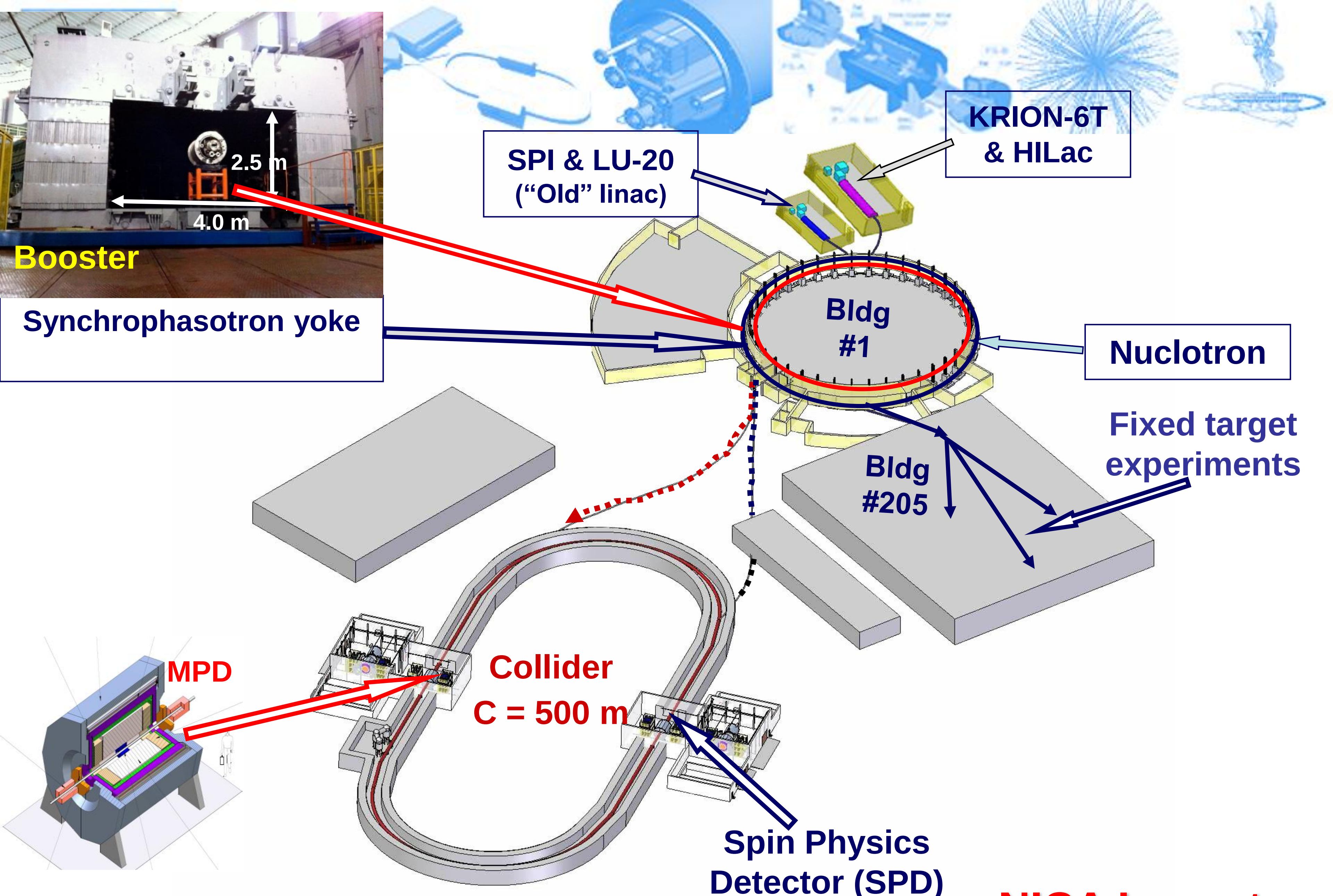
3) The beams of light ions and polarized protons and deuterons for fixed target experiments:

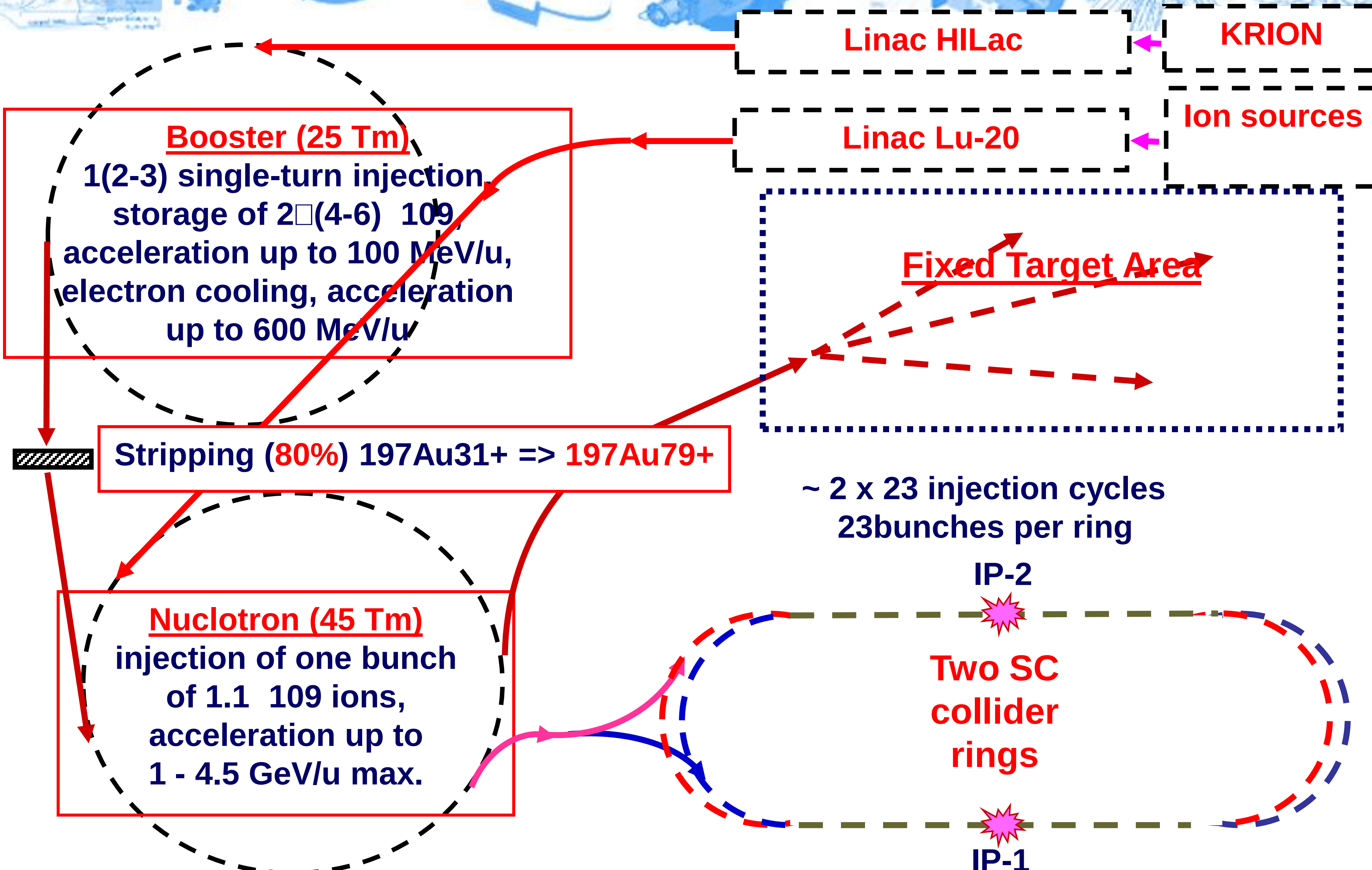
Li ÷ Au = 1 ÷ 4.5 GeV /u ion kinetic energy
p, p↑ = 5   12.6 GeV kinetic energy
d, d↑ = 2   5.9 GeV/u ion kinetic energy

4) Applied research on ion beams at kinetic energy

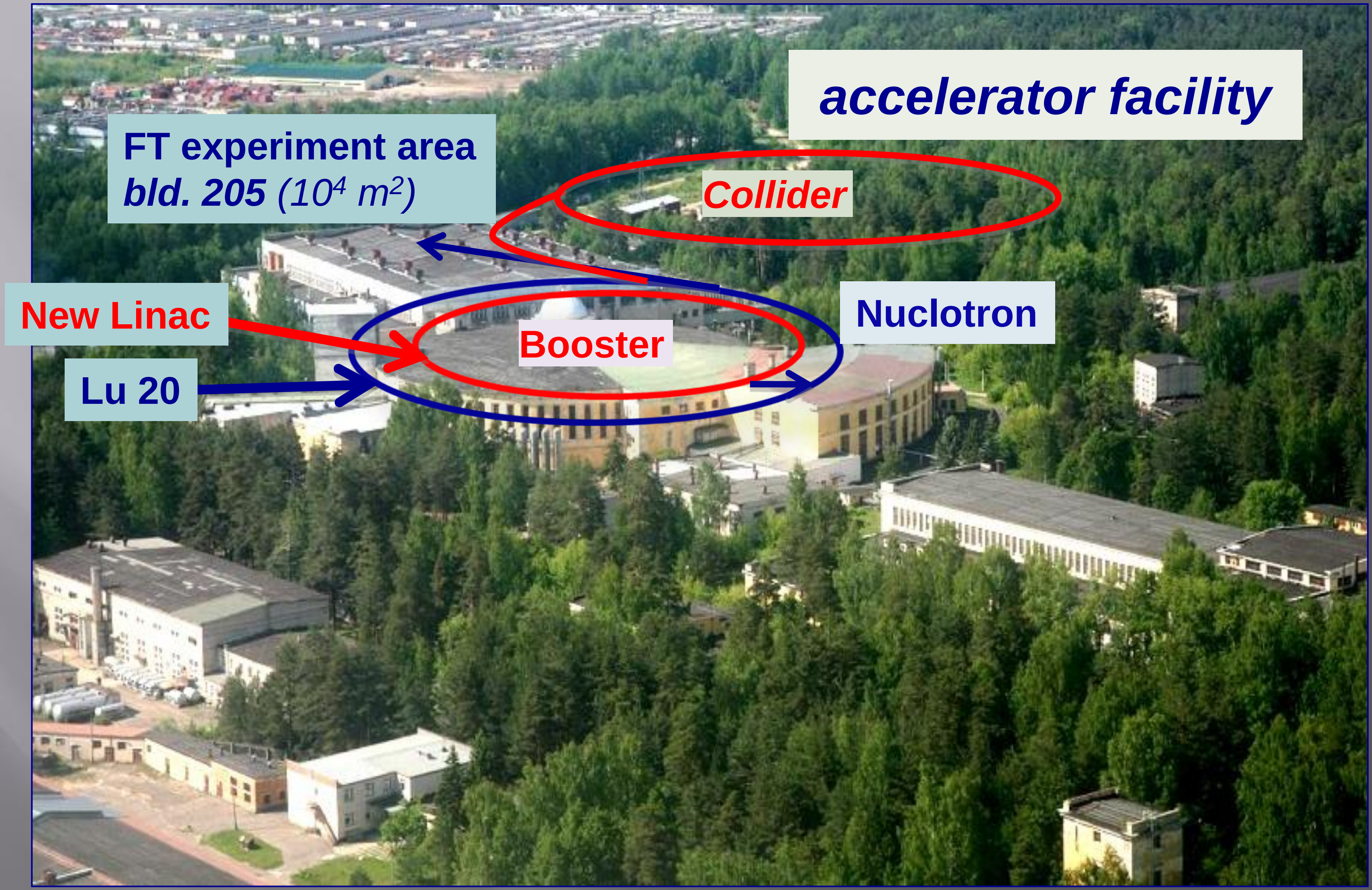
from 0.5 GeV/u up to 12.6 GeV (p) and 4.5 GeV /u (Au)

NICA Layout

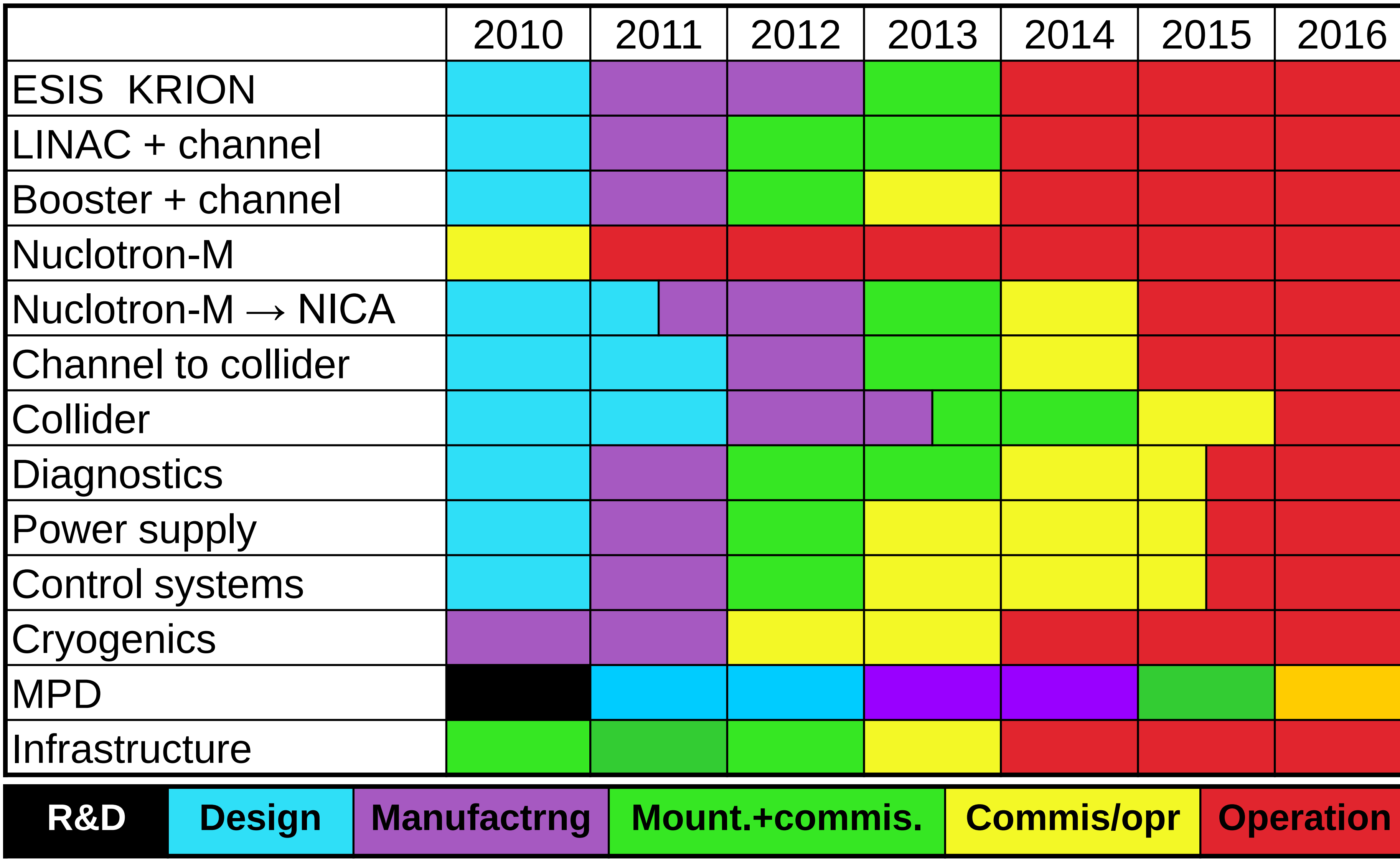

2.5 m
4.0 m
Booster
Synchrophasotron yoke
SPI & LU-20
("Old" linac)
KRION-6T
& HILac
Bldg
#1
Nuclotron
Fixed target
experiments
Bldg
#205
MPD
Collider
C = 500 m
Spin Physics
Detector (SPD)



Facility operation scenario


accelerator facility
FT experiment area
bld. 205 (10^4 m^2)
Collider
New Linac
Booster
Nuclotron
Lu 20

NICA construction schedule



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)***
- ***multi-strange 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

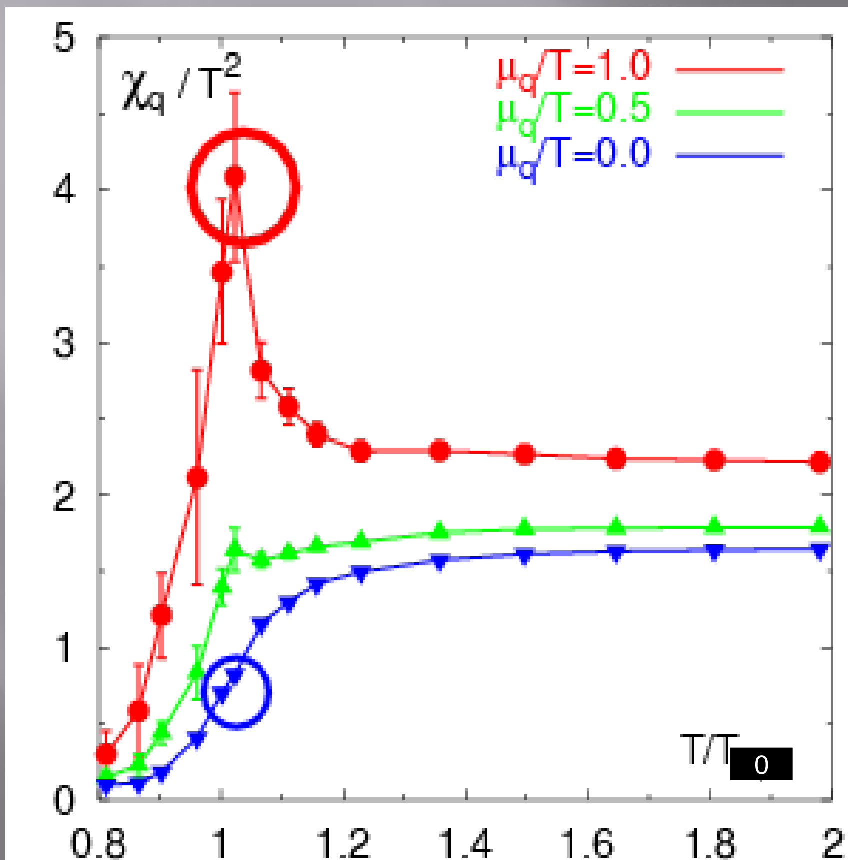
CSR – Chiral Symmetry Restoration
EOS – Equation Of State

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**

Fluctuations

Lattice QCD predictions: Fluctuations of the quark number density (susceptibility) at μ_B >0 (C.Allton et al., 2003)



$$\frac{\chi_q}{T^2} = \left[\frac{\partial^2}{\partial(\mu_q/T)^2}\frac{P}{T^4}\right]_{T\ fixed}$$

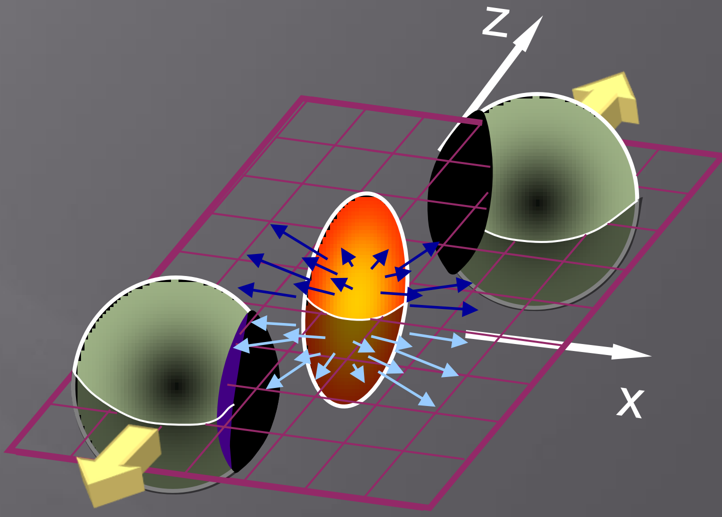
χ_q (quark number density fluctuations) will diverge at the critical end point

Experimental observation:

- **Baryon number fluctuations**
- **Charge number fluctuations**

Collective flows

Interactions between constituents lead to a pressure gradients => spatial asymmetry is converted in asymmetry in momentum space => collective flows



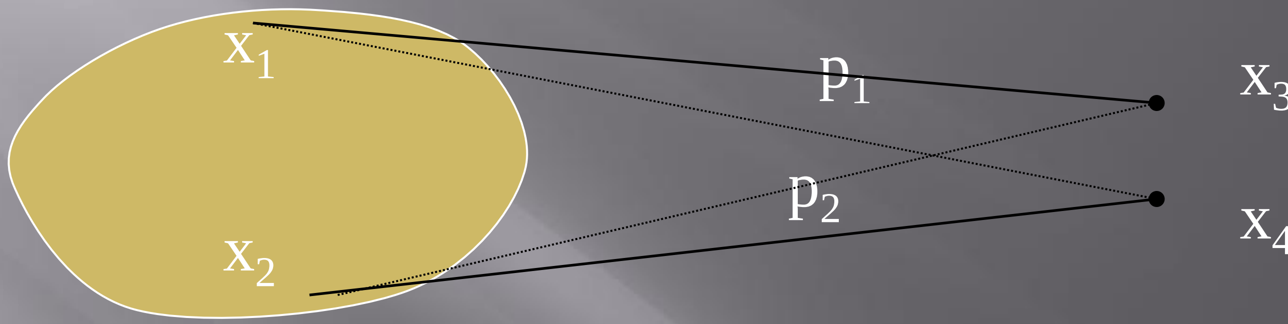
Non-central collisions

$$\frac{dN}{dy\,p_T\,dp_T\,d\varphi} = \frac{dN}{dy\,p_T\,dp_T}\,\frac{1}{2\pi}\left(1 + 2v_1\cos(\varphi) + 2v_2\cos(2\varphi) + \ldots\right)$$

directed flow

elliptic flow

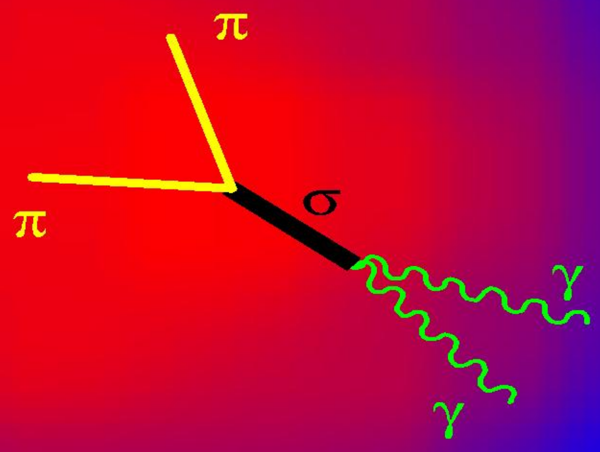
Correlation femtoscopy of identical particles



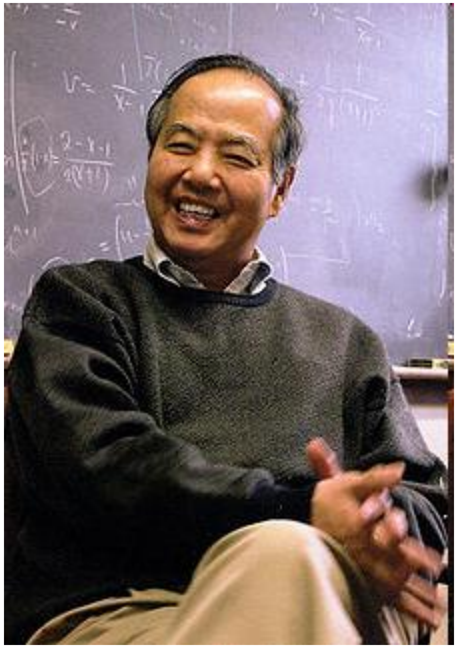
$q = p_1 - p_2$, $\Delta x = x_1 - x_2$

$$C_2 = 1 + (-1)^S < Cos\ q\Delta x > \rightarrow 1 + \lambda \exp(-R^2_{long} q^2_{long} - R^2_{side} q^2_{side} - R^2_{out} q^2_{out} - 2R^2_{out} q_{out} q_{long})$$

Signals of chiral symmetry restoration



Round Table Discussions I, *JINR, Dubna, 2005*
http://theor.jinr.ru/meetings/2005/roundtable/



From: "T.D. Lee" <tdl@phys.columbia.edu>
To: "Sisakian A.N." <sisakian@jinr.ru>
Sent: Wednesday, January 14, 2009 7:01 PM
Subject: Comment on the goals of the NICA heavy ion collider

Dear Prof. Sissakian:

The NICA heavy ion collider will be a very major step towards the formation of a new phase of quark-gluon matter.

The goal of relativistic heavy ion physics is to modify the properties of the physical vacuum. Of particular interest is a possibility to create a phase of quark-gluon matter where some of the fundamental symmetries may be altered. Recent RHIC results indicate that there may be an evidence of parity violation (on an event-by-event basis) in heavy ion collisions at high energies. It would be of great importance to search for this phenomenon in the energy range covered by the NICA collider where a high baryon density is reached.

I am very much looking forward to the completion and future success of the NICA heavy ion collider. Warm regards and very best wishes,

T. D. Lee
--
T. D. Lee
University Professor
Dept. of Physics - MC 5208
Columbia University
New York, NY 10027

Chiral Vortaic Effect and Neutron Asymmetries at NICA

O.Rogachevsky, A.Sorin, O.Teryaev

Phys. Rev. C82 054910, 2010

Both, chiral magnetic effect (CME) and chiral vortaic effect (CVE) belong to the class of effects based on the triangle anomaly in QFT. CVE is generalized to the conserved charges other than the electric one. In case of baryon charge and chemical potential, it should manifest itself by neutron asymmetries, which can be explored at NICA/MPD.

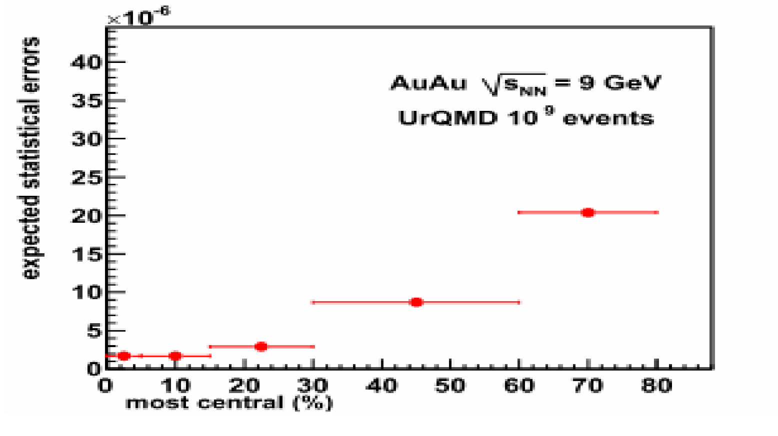
The crucial difference of CVE with respect to CME is due to a very small number of produced antibaryons, in particular, antineutrons. Therefore, no sign change for correlators is expected!

$$e_j A_\alpha J^\alpha \Rightarrow \mu_j V_\alpha J^\alpha$$

$$e_j \vec{H} \to \mu_j \vec{\nabla} \times \vec{V}$$

Observable: three-particle correlator: $\langle cos(\phi_\alpha + \phi_\beta - 2\phi_c)\rangle$

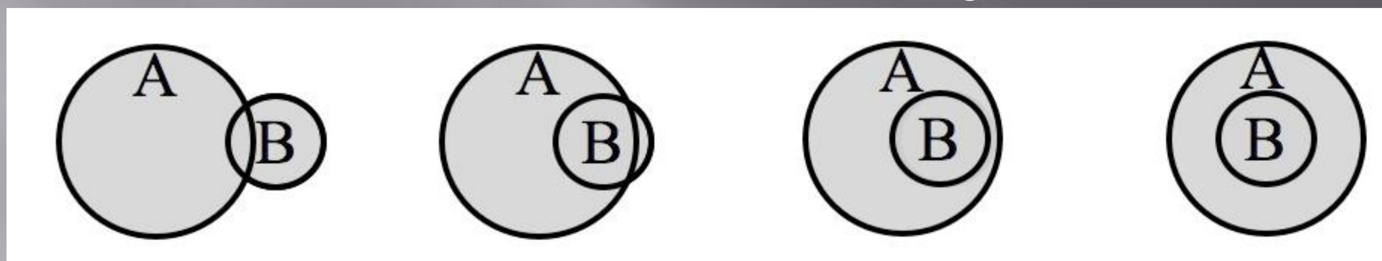
In CME case at RHIC: 15 M events were sufficient to establish the effect
For demonstrating the CVE, we need 1000 M events, which can be collected at NICA/MPD within a few months of running time!



The prospects for experimental study of directed, elliptic, and triangular flows in asymmetric heavy ion collisions at NICA energies

M.Bleicher (1,3), K.A.Bugaev (2), Ph.Rau (1,3),
A.S.Sorin (4), J.Steinheimer (1,3), H.Stoecker (1,5)

(1) Frankfurt Institute for Advanced Studies, Frankfurt, Germany
(2) Bogolyubov Institute for Theor. Physics, National Academy of Sciences of Ukraine
(3) Institut fur Theoretische Physik, Johann Wolfgang Goethe-Universitat, Frankfurt
(4) Joint Institute for Nuclear Research, Dubna
(5) GSI Helmholtzzentrum fur Schwerionenforschung, D-64291 Darmstadt, Germany



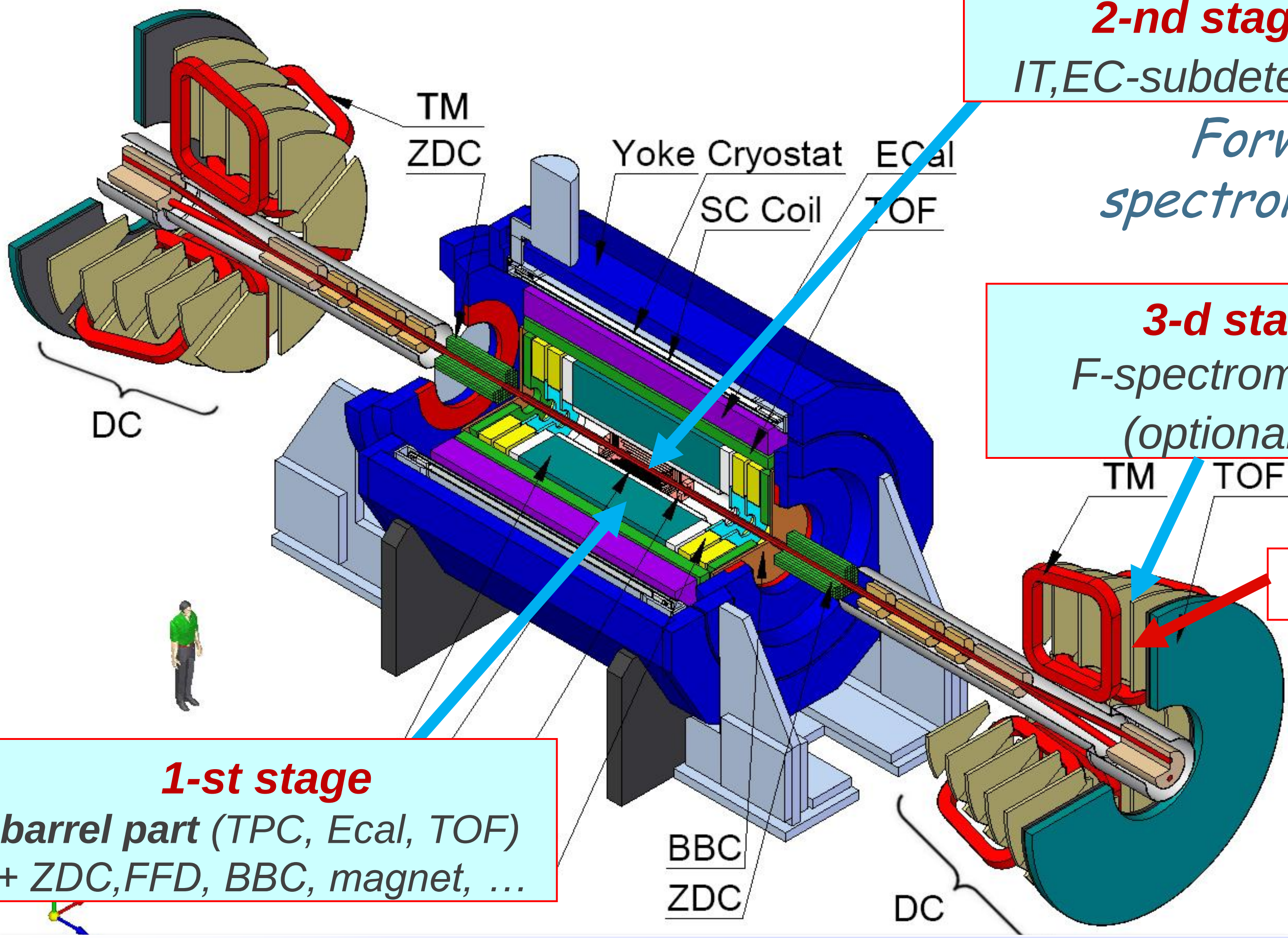
Proposal: arXiv:1106.3647

$$\frac{dN}{dyp_T dp_T d\varphi} = \frac{dN}{dyp_T dp_T}\frac{1}{2p}\left(1 + 2v_1\cos(\varphi) + 2v_2\cos(2\varphi) + \ldots\right)$$

To explore asymmetric nuclear collisions (ANS) both with extracted Nuclotron beams up to 5 AGeV and with a center of mass energy up to 11 AGeV in the NIICA collider mode. In framework of UrQMD transport model, ANS directed, elliptic, and triangular flows have a very rich and complicated structure of energy and centrality dependencies compared to the flows in symmetric nuclear collisions worth to be investigated experimentally. In addition, ANS directed, elliptic, and triangular flow coefficients for collisions with existing density fluctuations in the target nucleus crucially differ from those obtained in absence of such fluctuations. Such ANS may allow one to reach highest baryonic charge densities and, perhaps, to study a mixed quark-hadron phase even at the Nuclotron energy range. ANS flow patterns are very sensitive to the details of the employed interaction which can be used both for tuning of the transport codes and for elucidation of essential features of hadron interactions in the medium.

MultiPurpose Detector (MPD)

3 stages of putting into operation



2-nd stage
IT,EC-subdetectors

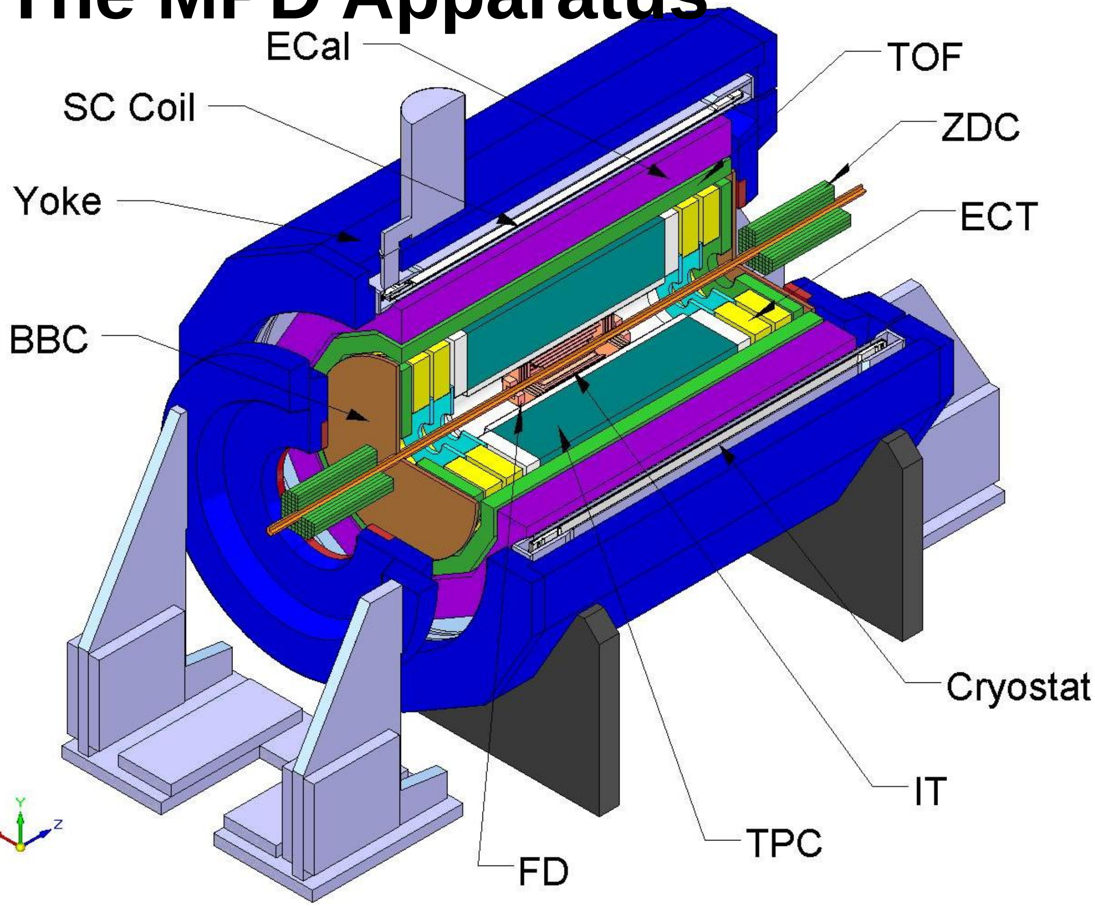
Forward spectrometer-B

3-d stage
F-spectrometers (optional ?)

Toroid

1-st stage
***barrel part** (TPC, Ecal, TOF) + ZDC,FFD, BBC, magnet, …*

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

http://nica.jinr.ru

Version 1.4

The MultiPurpose Detector – MPD

to study Heavy Ion Collisions at NICA
(Conceptual Design Report)

Project leaders: A.N. Sissakian, A.S. Sorin, V.D. Kekelidze

Editorial board:
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N.Gorbunov, V.Kolesnikov, I.Meshkov, A.Olshevski, Yu.Potrebenikov, N.Topilin, I.Tyapkin, Yu.Zanevsky, A.Kurepin

The MPD Collaboration:[1]

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The size of the Collaboration is growing continuously and new members are welcome!

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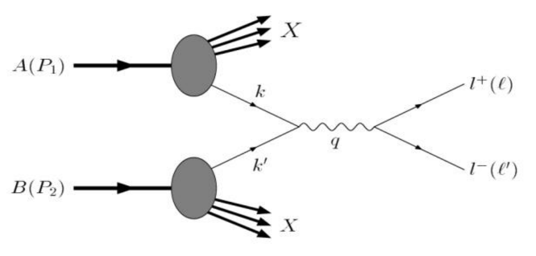
Spin Physics at NICA

EMC, 1987 $\Delta\Sigma = 0.12 \pm 0.17$

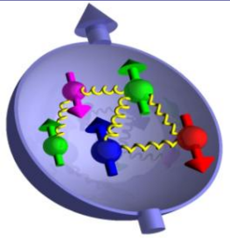
Polarization data has often been the graveyard for fashionable theories. If theorists had their way they might well ban such measurements altogether out of self-protection.

J.D. Bjorken, 1987

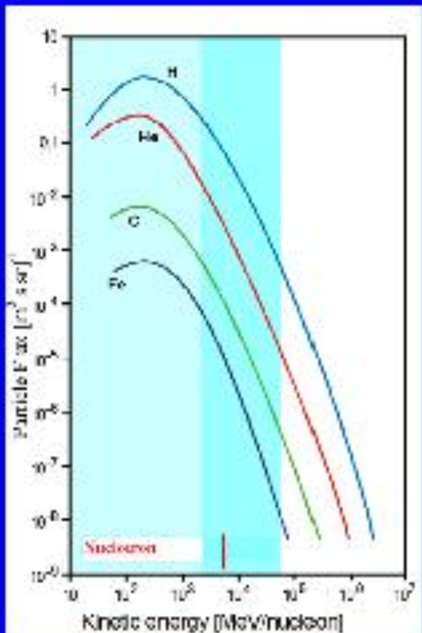
Preliminary topics:



- *DY processes with L&T polarized p & D beams*: *extraction of unknown (poor known) PDF*
- *PDFs from J/y production processes*
- *Spin effects in baryon, meson and photon productions*
- *Spin effects in various exclusive reactions*
- *Diffractive processes*
- *Cross sections, helicity amplitudes & double spin asymmetries (Krisch effect) in elastic reactions*
- *Spectroscopy of quarkoniums with any available decay modes*
- *Polarimetry*



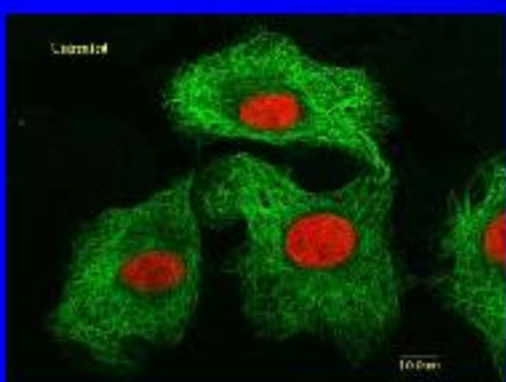
NICA and Space Radiobiology

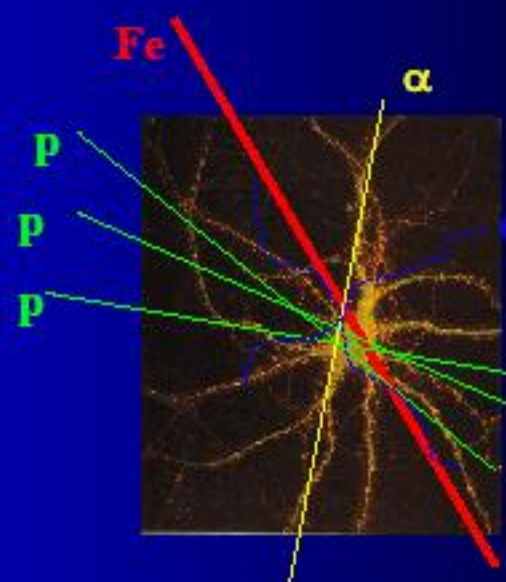


Energetic spectrum of Galactic heavy ions

Consequences of action of Galactic heavy ions for Mars mission:

- ❖ Induction of cancer;
- ❖ Formation of gene and structural mutations;
- ❖ Violation of visual functions:
- ❖ lesions of retina;
- ❖ cataract induction;
- ❖ Violation of nervous system function.





Nuclotron-M/NICA

- **JINR HEP** basic facility (*in operation since* **’93)**
  based on the unique technology of ***super-conducting fast cycling magnets*** *developed in JINR*
- provides proton, **polarized** deuteron
  & multi charged ion beams

Nuclotron development:

- **Nuclotron-M** *(vacuum, PS, orbit corr. +…)*
  completed in **2010**
- **Nuclotron-NICA** *(Krion-6T, SPI, RF, new Linac +…)*
  to be fulfilled in ***2014***

The goal:

- acceleration of heavy ions -> $^{197}Au^{79+}$
- energy ~ 4.5 GeV/u
- beam intensity ~ 10^9 A/cycle

Beam	Nuclotron beam intensity (particle per cycle)		
	Current	Ion source type	New ion source + booster
p	$3 \cdot 10^{10}$	Duoplasmotron	$5 \cdot 10^{12}$
d	$3 \cdot 10^{10}$	--- ,, ---	$5 \cdot 10^{12}$
^{4}He	$8 \cdot 10^{8}$	--- ,, ---	$1 \cdot 10^{12}$
d↑	$2 \cdot 10^{8}$	SPI	$1 \cdot 10^{10}$
^{7}Li	$8 \cdot 10^{8}$	Laser	$5 \cdot 10^{11}$
$^{11,10}B$	$1 \cdot 10^{9,8}$	--- ,, ---	
^{12}C	$1 \cdot 10^{9}$	--- ,, ---	$2 \cdot 10^{11}$
^{24}Mg	$2 \cdot 10^{7}$	--- ,, ---	
^{14}N	$1 \cdot 10^{7}$	ESIS (“Krion-6T”)	$5 \cdot 10^{10}$
^{24}Ar	$1 \cdot 10^{9}$	--- ,, ---	$2 \cdot 10^{11}$
^{56}Fe	$2 \cdot 10^{6}$	--- ,, ---	$5 \cdot 10^{10}$
^{84}Kr	$1 \cdot 10^{4}$	--- ,, ---	$1 \cdot 10^{9}$
^{124}Xe	$1 \cdot 10^{4}$	--- ,, ---	$1 \cdot 10^{9}$
^{197}Au	-	--- ,, ---	$1 \cdot 10^{9}$

The modernization stages and the beams provided by the Nuclotron:

Beam	Intensities, particles per cycle				
	Energy	GSI (SIS18)	Nuclotron-M (2010)	Planned with Nuclotron-N (2012)	Planned with new ion source and booster (2014-2015)
p	4.5 GeV	$2 \cdot 10^{10}$	$8 \cdot 10^{10}$	$5 \cdot 10^{11}$	$5 \cdot 10^{12}$
d	2.2 GeV	$5 \cdot 10^{11}$	$8 \cdot 10^{10}$	$5 \cdot 10^{11}$	$5 \cdot 10^{12}$
^{4}He			$2 \cdot 10^{9}$	$3 \cdot 10^{10}$	$1 \cdot 10^{12}$
$d \uparrow$			$2 \cdot 10^{8}$	$7 \cdot 10^{10}$ (SPI)	$7 \cdot 10^{10}$ (SPI)
$^{7}Li^{6+}$			$7 \cdot 10^{9}$	$3 \cdot 10^{10}$	$5 \cdot 10^{11}$
$^{12}C^{6+}$	300 MeV	$7 \cdot 10^{10}$	$6 \cdot 10^{9}$	$3 \cdot 10^{10}$	$3 \cdot 10^{11}$
$^{24}Mg^{12+}$	300 MeV	$5 \cdot 10^{10}$	$7 \cdot 10^{8}$	$4 \cdot 10^{9}$	$5 \cdot 10^{10}$
$^{40}Ar^{18+}$	300 MeV	$6 \cdot 10^{10}$	$8 \cdot 10^{6}$	$2 \cdot 10^{9}$	$2 \cdot 10^{11}$
$^{56}Fe^{28+}$			$4 \cdot 10^{6}$	$2 \cdot 10^{9}$	$5 \cdot 10^{10}$
$^{58}Ni^{26+}$	300 MeV	$8 \cdot 10^{9}$			
$^{84}Kr^{34+}$	0.3-1 GeV	$2 \cdot 10^{10}$	$2 \cdot 10^{5}$	$1 \cdot 10^{8}$	$1 \cdot 10^{9}$
$^{124}Xe^{48/42+}$	0.3-1 GeV	$1 \cdot 10^{10}$	$1 \cdot 10^{5}$	$7 \cdot 10^{7}$	$1 \cdot 10^{9}$
$^{181}Ta^{61+}$	1 GeV	$2 \cdot 10^{9}$			
$^{197}Au^{65/79+}$		$3 \cdot 10^{9}$		$1 \cdot 10^{8}$	$1 \cdot 10^{9}$

Preparation of the experiment on the study of the Strange Matter production at the fixed target at Nuclotron

Collaboration GSI-JINR-...

Goal of the experiment

Measurements of the multistrange objects (Ξ, Ω, exotics) and hypernuclei in heavy ions collisions using extracted beams at Nuclotron close to the threshold production

The detector for the first stage of the experiment will be based on the developments for CBM, MPD and SPD

Strange matter production in heavy ion collisions at the Nuclotron extracted beam

- Collaboration **GSI-JINR**

- The ultimative goal of the experiment is the systematic measurements of the observables for multistrange objects (Ξ^-, Ω^-, $\Lambda\Lambda$ etc.) in Au-Au collisions in the energy domain of the Nuclotron extracted beam (up to 5 A GeV)

NICA

energy of beams extracted from Nuclotron

covers the gap between SIS-18 and AGS *(with some overlaps)*

	Z/A	***max*** $\sqrt{s_{NN}}$ *(GeV/n)*	***max.*** T_{kin} *(GeV/n)*
p	***1***	***≈ 5.2***	***≈ 12***
d	***1/2***	***≈ 3.8***	***≈ 5.7*** *(including polarized deuterons)*
Au	***0.4***	***≈ 3.5***	***≈ 4.5*** *(at **2T** in dipoles)*

These allow:

- *study of dense baryonic matter at temperatures up to **100** MeV,*
- *(multi)-strangeness (open & hidden) production in dense baryonic matter,*
- *modification of particle properties in dense nuclear matter*

The corresponding multi-purpose setup

Baryonic Matter at Nuclotron (BM@N)

Study of dense baryonic matter at < 6 GeV/n

Physics is complementary to the MPD program
& will be actual even after start of the MPD runs:

- **AA interactions:**
  - *particle production, including subthreshold production;*
  - *particle(collective) flows, event-by-event fluctuations, correlations;*
  - *multiplicities, phase space distributions of p, n, π, K, hyperons, light nuclear fragments, vector mesons, hadronic resonances, direct light hypernuclei production in central AA collisions.*
  - *ratios of yields (π/K etc) in different kinematical regions*.

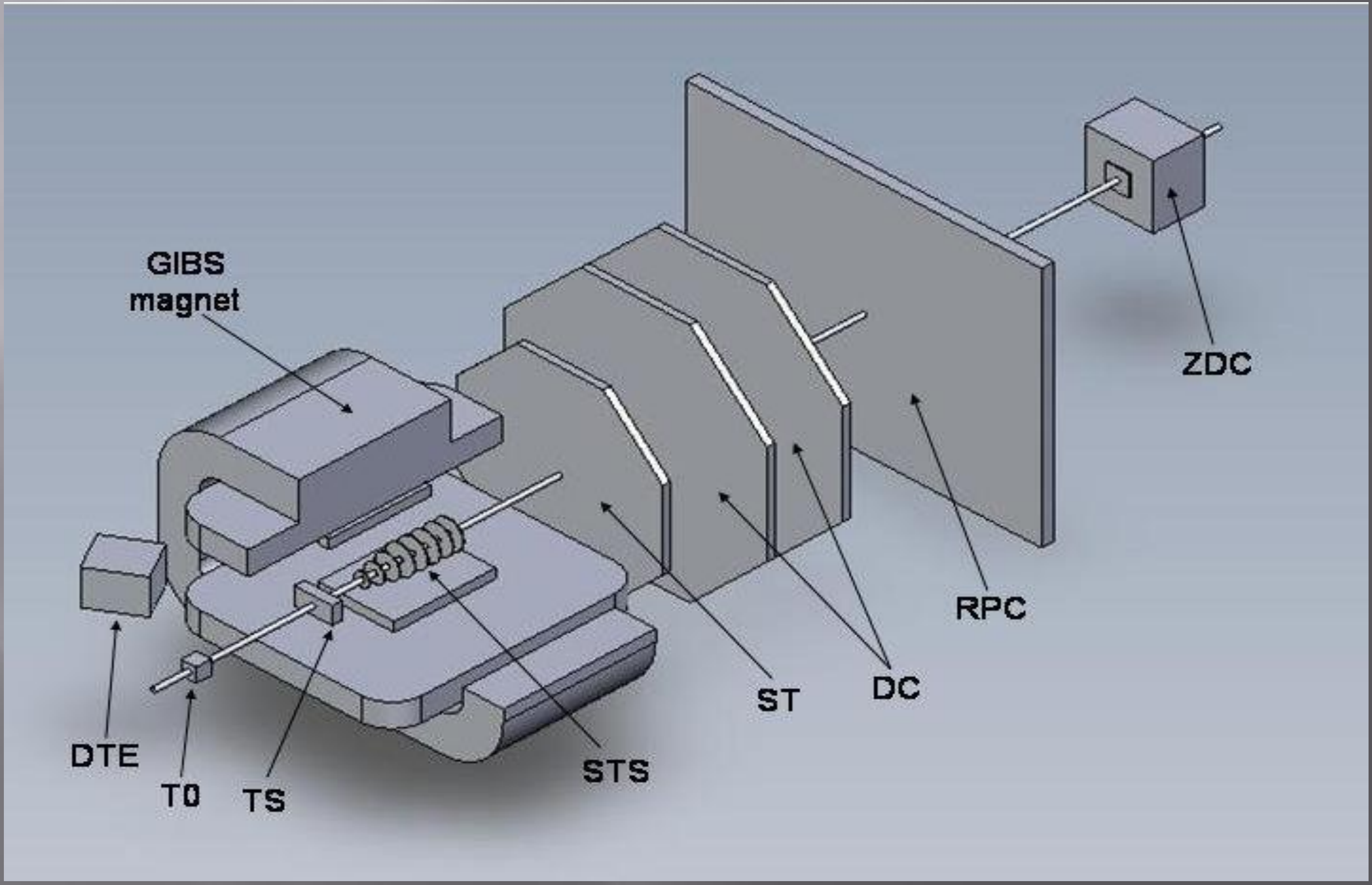
- **pA, nA, dA interactions in direct & inverse (Ap, Ad) kinematics:**
  - *to get a "reference" data set for comparison with AA interactions,*
  - *to investigate particle modifications in hadronic matter advantages of the inverse kinematics (Ap, Ad collisions) may play significant role*
  - *to look for polarization effects in particle production off nuclear targets by polarized d, p, n.*

Spin physics

- Structure of light nuclei using spin-dependent observables
  (*analyzing powers, spin-spin correlations)*
- Polarization effects in subthreshold particle production
- Polarization effects (asymmetries, spin-spin correlations)
  in inclusive reactions in dependence on p_T
  using polarized beams & polarized target
  (π, K, hyperons etc.)
- Polarization effects (asymmetries) in meson production
  in “cumulative” region
- Polarization effects in elastic and binary reactions
  (filling white spots in the world NN data base)
- Use of polarized beams to calibrate polarimeters
  For experiments in multi-GeV region.

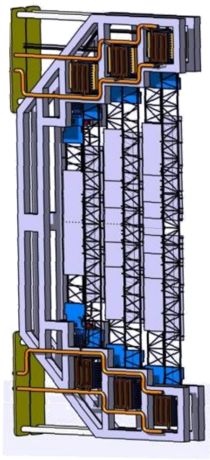
**Collaborations with USA (JLAB), Japan (RIKEN, RCNP),
Slovak Republic, Czech Republic**

Large Acceptance Magnetic Spectrometer for Heavy Ions Collisions at Nuclotron



Main subdetectors for the fixed target experiment at Nuclotron beam

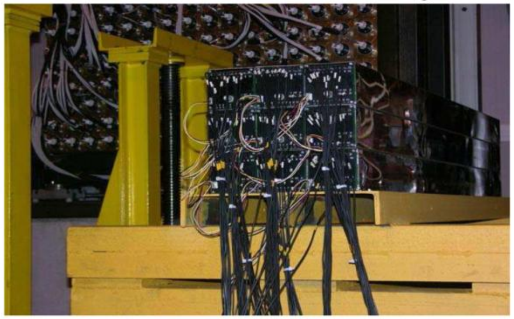
Silicon Tracker System (CBM-GSI)



Outer Tracker (NA48-CERN/JINR)

TOF-MRPCs (MPD-JINR)

ZDC (INR-JINR)



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**

NICA

Draft v 5.01
June 20, 2011

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

NICA White Paper

SEARCHING for a QCD MIXED PHASE at the

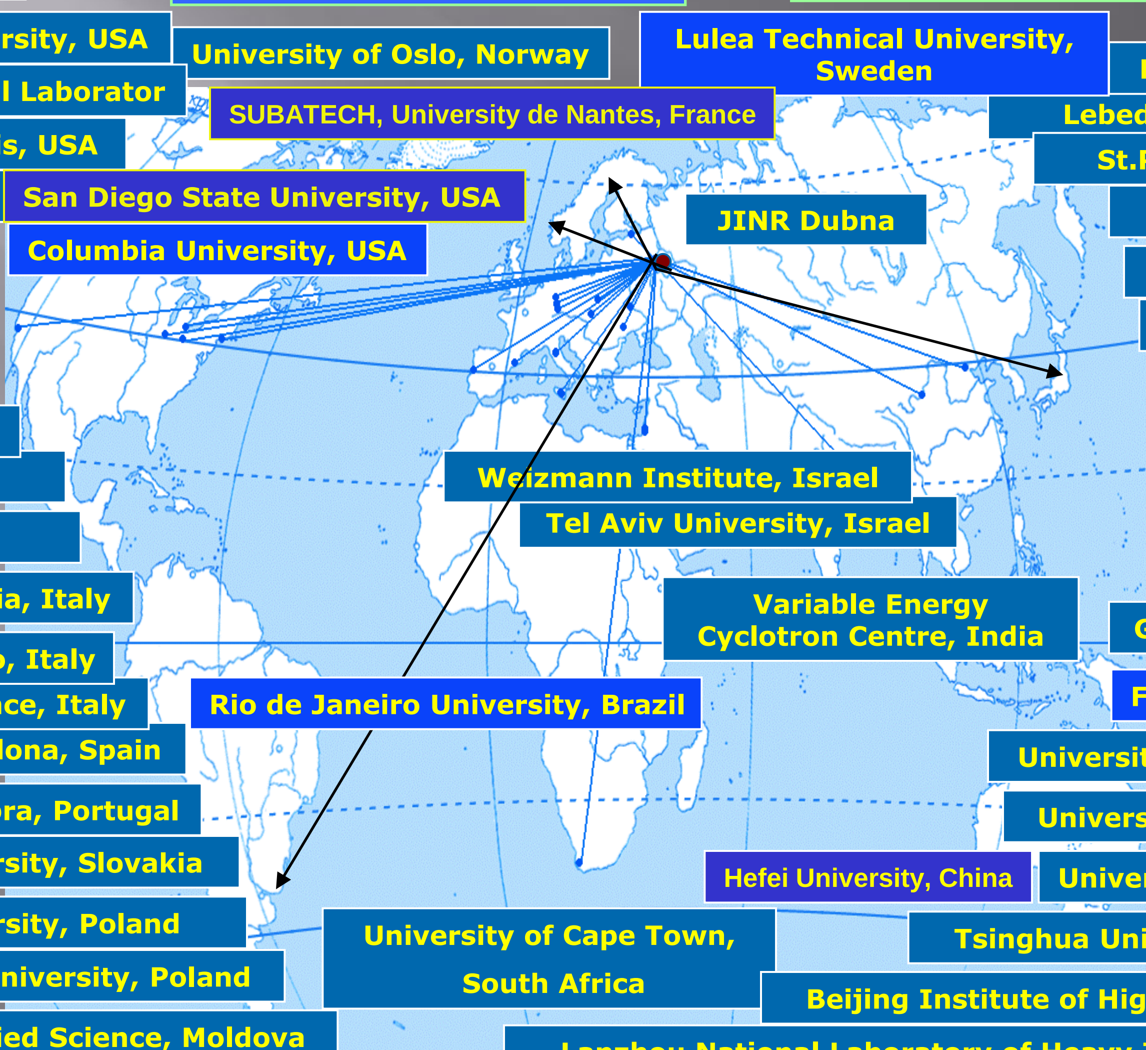
NUCLOTRON-BASED ION COLLIDER FACILITY

The final goal of the NICA White Paper is to address the following key topics:

- Phases of dense QCD matter and conditions for their possible realization
- Characteristic processes as indicators of phase transformations
- Estimates of various observables for events
- Comparison to other experiments

The NICA White Paper

140 authors *from* **56 scientific centers** *in* **21 Countries (8 JINR members)**



Arizona State University, USA
University of Oslo, Norway
Lulea Technical University, Sweden
Kurchatov Institute, Russia
Los Alamos National Laborator
SUBATECH, University de Nantes, France
Lebedev Institute, Russia
University of Illinois, USA
St.Petersburg SU, Russia
Wayne SU, USA
San Diego State University, USA
JINR Dubna
IHEP, Russia
LBNL, USA
Columbia University, USA
ITEP, Russia
BNL, USA
INP MSU, Russia
Ohio SU, USA
MEPhI, Russia
BITP, Ukraine
INR, Russia
INFN, Italy
Weizmann Institute, Israel
Tel Aviv University, Israel
Osaka University, Japan
SISSA, Italy
YITP Kyoto, Japan
University of Catania, Italy
Variable Energy Cyclotron Centre, India
GSI Darmstadt, Germany
University of Trento, Italy
FIAS Frankfurt, Germany
University of Florence, Italy
Rio de Janeiro University, Brazil
University of Barselona, Spain
University of Frankfurt, Germany
University of Coimbra, Portugal
University of Giessen, Germany
Mateja Bela University, Slovakia
Hefei University, China
University of Bielefeld, Germany
Wroclaw University, Poland
University of Cape Town, South Africa
Tsinghua University, Beijing, China
Jan Kochanovski University, Poland
Beijing Institute of High Energy Physics, China
Institute of Applied Science, Moldova
Lanzhou National Laboratory of Heavy Ion Accelerator, China

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

NICA White Paper - Contents

(68 contributions)

Section 1: Editorial

1.1 Physical phenomena and relevant observables:

- in-medium modification of hadron properties (MMH)
- the nuclear matter equation of state (EoS);
- the onset of deconfinement (OD) and/or
- chiral symmetry restoration (CSR);
- signals of a phase transition (PT);
- the mixed phase and the critical end-point (CEP);
- possible local parity violation in strong interactions (LPV).

The correlations between observables and physical phenomena:

Observables	Physical Phenomena							Reference in the White Paper
	MMH	EoS	OD	CSR	PT	CEP	LPV	
hadron and light nuclei yields	x	x	x	x				3.6, 3.9, 4.3, 3.11, 4.12
yields and spectra of multi-strange hyperons	x	x	x					2.6, 6.4, 12.3, 5.3
electromagnetic probes			x	x				7.1, 7.2, 7.3, 7.7
azimuthal charged particle correlations					x		x	8.1 - 8.6, 10.4
event-by-event (EBE) fluctuations						x		2.1, 2.6, 3.10, 5.4
EBE directed, elliptic and triangular flow of hadrons		x	x		x			4.4, 4.8, 5.8
higher moments of hadron distributions			x		x	x		3.10, 4.5, 4.6, 4.10
interferometric parameters		x			x			3.5, 5.1, 5.2, 5.5

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/

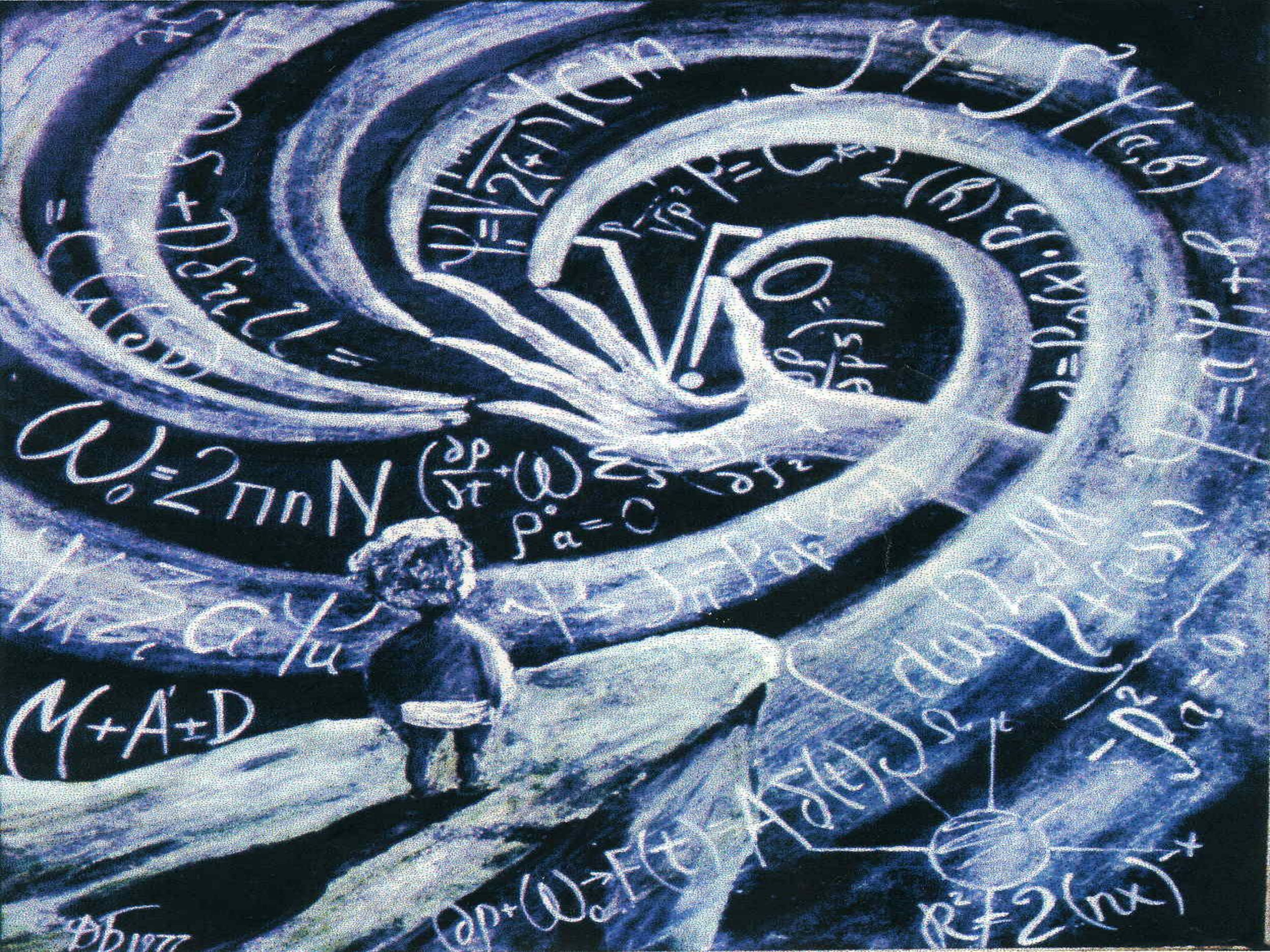
Round Table Discussion II: Searching for the mixed phase of strongly interacting matter at the JINR Nuclotron: Nuclotron facility development JINR, Dubna, October 6 - 7, 2006
http://theor.jinr.ru/meetings/2006/roundtable/

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

The meeting with the cosmonauts Yi So-Yeon (South Korea), Yu. Baturin and A. Balandin (Russia)



$\omega_0 = 2\pi n N$
M+A±D

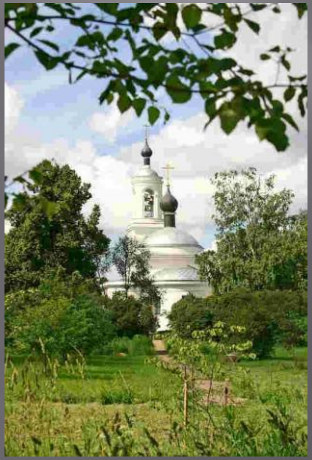
Welcome to the collaboration!

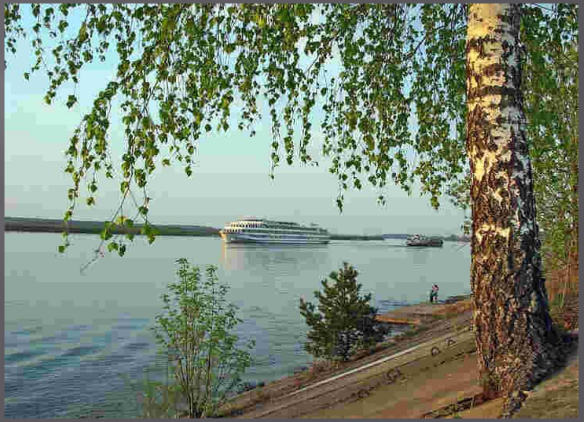
Thank you for attention!

Welcome to Dubna!

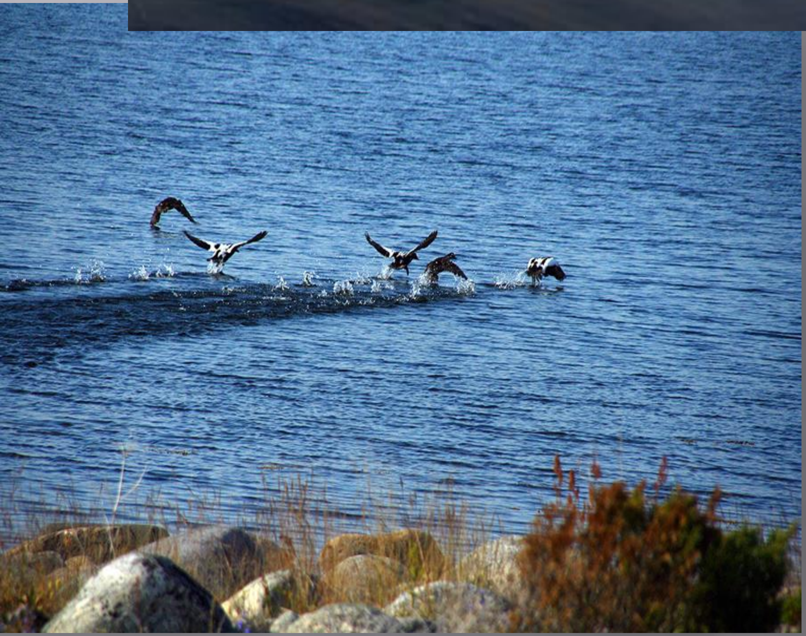



Dubna Sightseeing













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JINR

Dubna

Welcome to JINR (Dubna)

A vitally important task is attracting of young people from all the Member States to science

EDUCATIONAL PROGRAMME

JINR UNIVERSITY CENTRE

More than 300 students and postgraduates from Member States are trained at the UC

Chairs: MSU | MIPT | MEPI | MIREA | theros

JINR is a school of excellence for the Member States!

"Dubna" International University

BLTP

DIAS - TH

Dubna International Advanced School on Theoretical Physics

The UC offers graduate programmes in the fields of:

- ♦ Elementary Particle Physics
- ♦ Nuclear Physics
- ♦ Theoretical Physics
- ♦ Condensed Matter Physics
- ♦ Technical Physics
- ♦ Radiobiology

Bogoliubov Laboratory of Theoretical Physics

Dubna International Advanced School of Theoretical Physics

DIAS-TH at JINR : Standing Activity

- DIAS-TH is a substructure of BLTP supported by the JINR's budget as one of priority activities of the Institute.
- DIAS-TH organizes and controls all educational programmes for young scientists, graduates, and students.
- DIAS-TH programme includes both the standing activity through the year and the standard short schools (about 4 - 5 in a year).

The main goals of DIAS-TH:

- training courses for young scientists, graduates and undergraduates from the JINR MS and other countries
- looking for and supporting gifted young theorists in the JINR Member States
- creating databases of students and young researchers;
- organization of schools of different level in Dubna
- coordination with similar schools in the JINR MS, Germany, and other cntrs.
- support of the JINR and CERN experimental programmes by organizing lecture courses and lectures with a special emphasis on the LHC program
- coordination with the schools and workshops supported by CERN, UNESCO, ICTP, and other organizations
- publication and distribution of lectures and discussions in different forms, in particular, with the use of modern electronic means, etc.