Joint Institute for Nuclear Research
International Intergovernmental Organization

Status of the NICA Project at JINR

A.N.Sissakian, A.S.Sorin
(for the NICA collaboration)

WINTER SCHOOL ON HEAVY ION PHYSICS
Budapest, November 30, 2009

I. Status of the NICA project at JINR

The main goal of the NICA project is an experimental study of hot and dense nuclear matter and spin physics

These goals are proposed to be reached by:

- development of the Nuclotron as a basis for generation of intense beams over atomic mass range from protons to uranium and light polarized ions;

- design and construction of heavy ion collider with maximum collision energy of $\sqrt{s_{NN}}$ = 11 GeV and average luminosity ~ 10^{27} cm^{-2} s^{-1} (for Au^{79+}), and polarized proton beams with energy $\sqrt{s}$ ~ 26 GeV and average luminosity > 10^{30} cm^{-2} s^{-1}
- design and construction of the MultiPurpose Detector (MPD)

The NICA Project Milestones

• **Stage 1: years 2007 – 2011**
- Upgrade and Development of the Nuclotron
- Preparation of Technical Design Report of the NICA and MPD
- Designing MPD and NICA elements

• **Stage 2: years 2010 – 2013**
Manufacturing and mounting NICA and MPD

• **Stage 3: year 2014**
-Commissioning

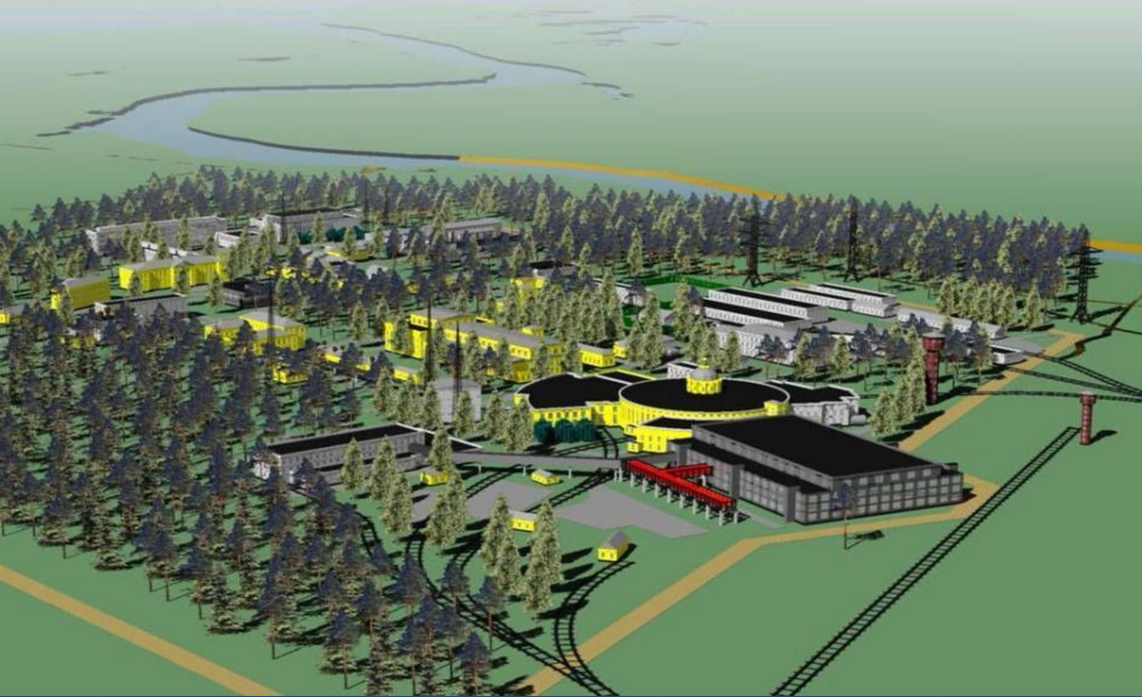
• **Stage 4: year 2015**
- Operation

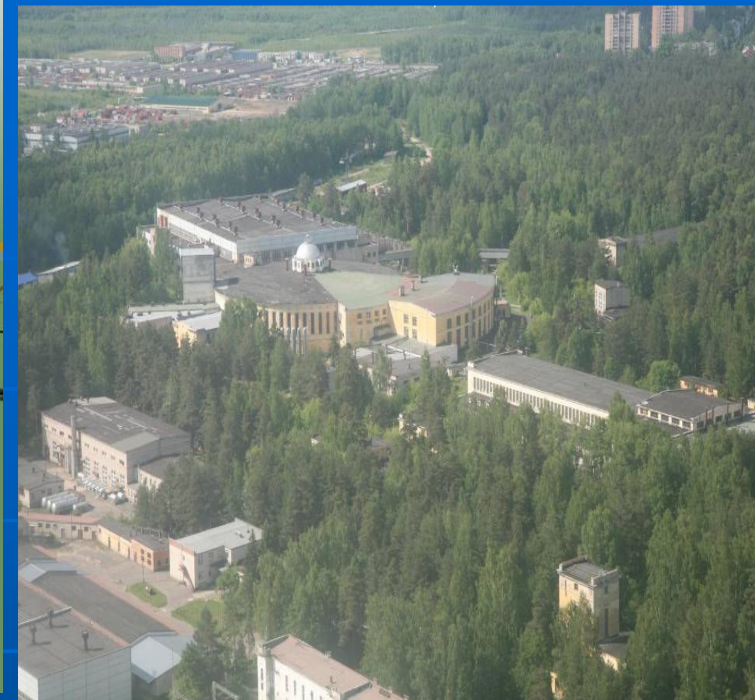
The Basic Conditions for the Project Development

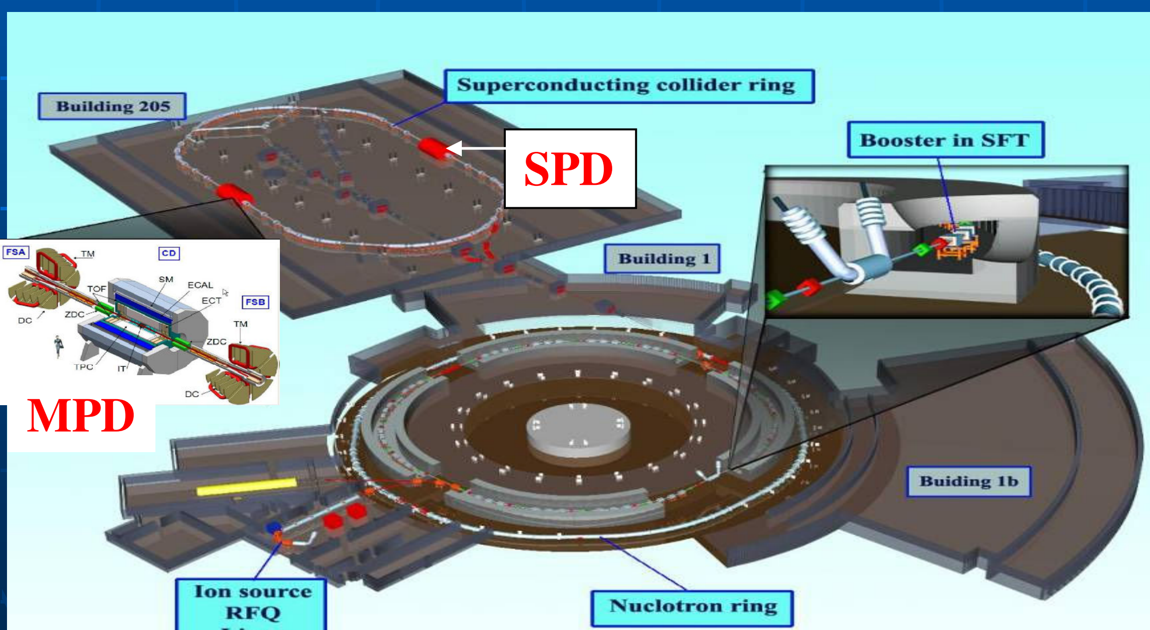
1. Minimum of R & D
2. Application of existing experience
3. Co-operation with experienced research centers
4. Cost: as low as possible
5. Realization time: 6 – 7 years

Consequences

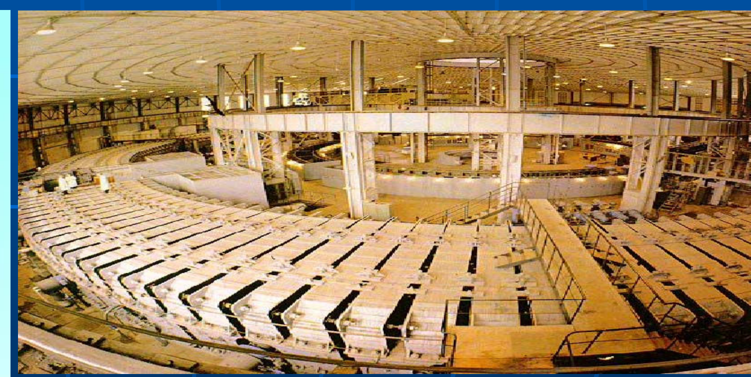
1. Choice of an existing building for dislocation of the collider
2. Collider circumference is limited by ~ 250 m



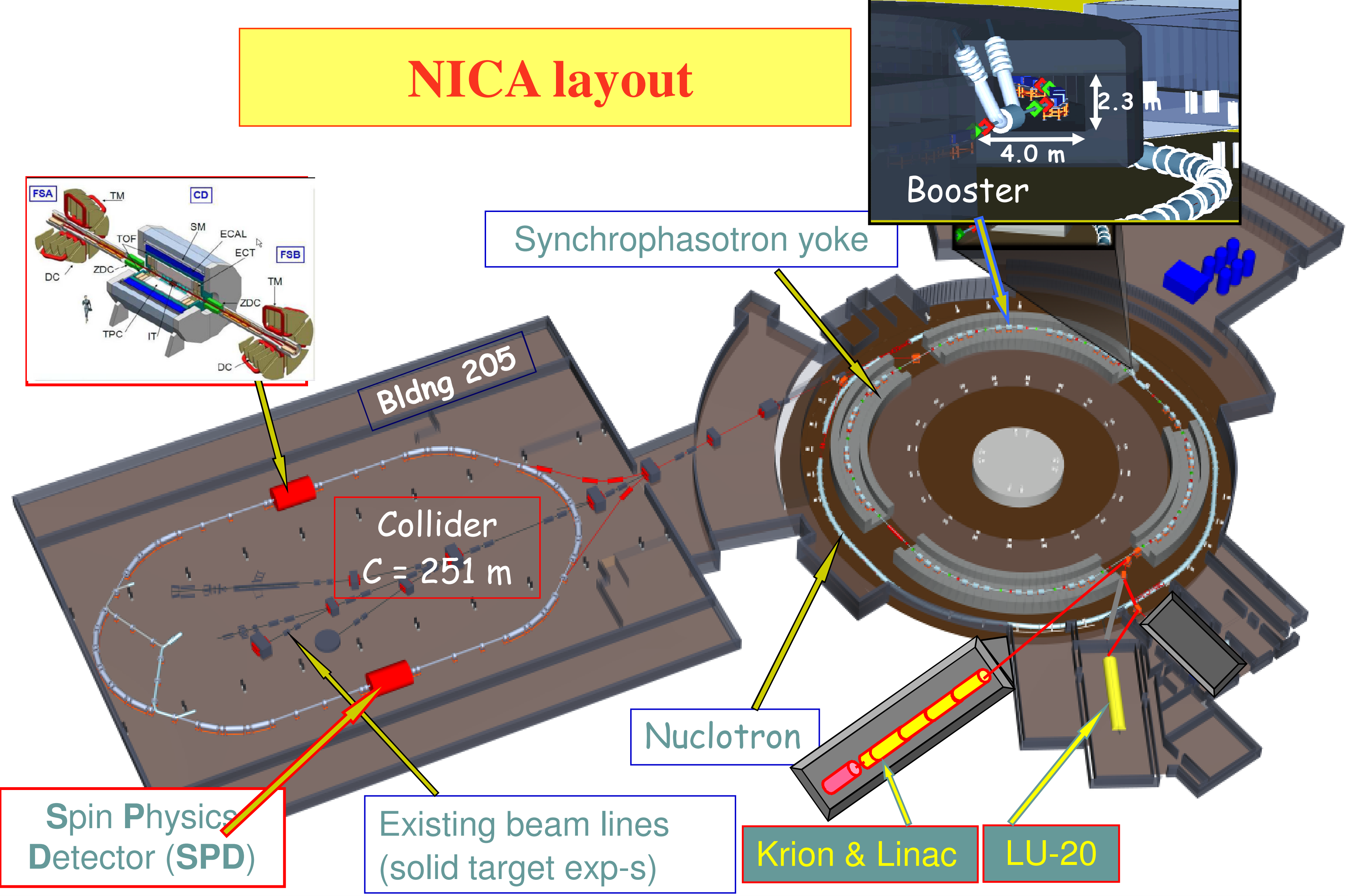




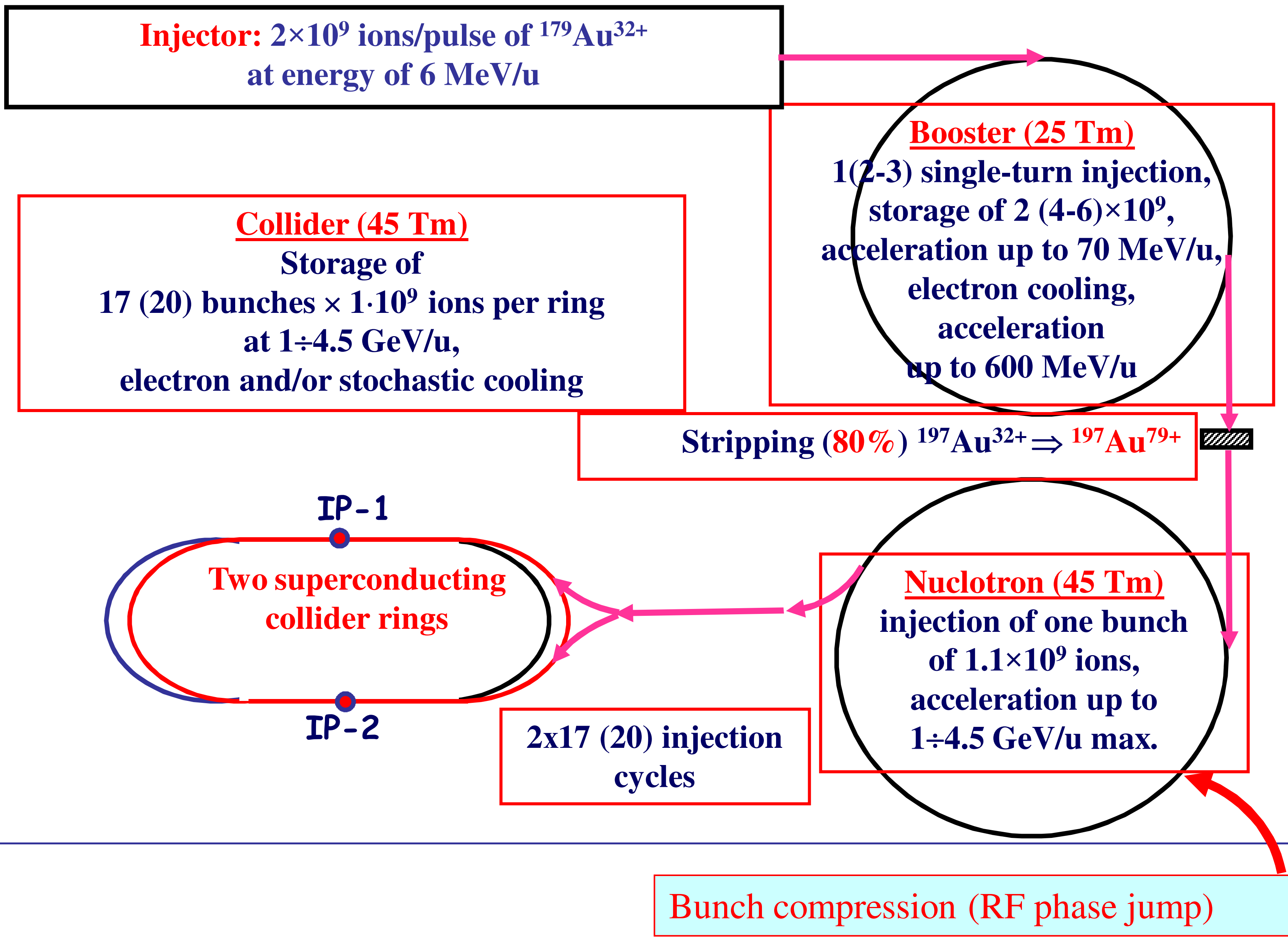
NICA general layout



NICA layout


FSA
TM
CD
SM
ECAL
TOF
ECT
FSB
DC
ZDC
TM
ZDC
TPC
IT
DC
Booster
2.3 m
4.0 m
Synchrophasotron yoke
Bldng 205
Collider
C = 251 m
Nuclotron
Spin Physics Detector (SPD)
Existing beam lines
(solid target exp-s)
Krion & Linac
LU-20

Scheme of the NICA compex



NICA Collaboration

- Joint Institute for Nuclear Research
- Institute for Nuclear Research Russian Academy of Science
- Institute for High Energy Physics, Protvino
- Budker Institute of Nuclear Physics, Novosibirsk
- ITEP
- All-Russian Institute for Electrotechnique
- Corporation “Powder Metallurgy” (Minsk, Belorussia):
- MoU with GSI
- FZ Jűlich (IKP)
- BNL (RHIC)
- Fermilab
- *Open for extension …*

JOINT INSTITUTE FOR NUCLEAR RESEARCH

Design and Construction of
Nuclotron-based Ion Collider fAcility (NICA)

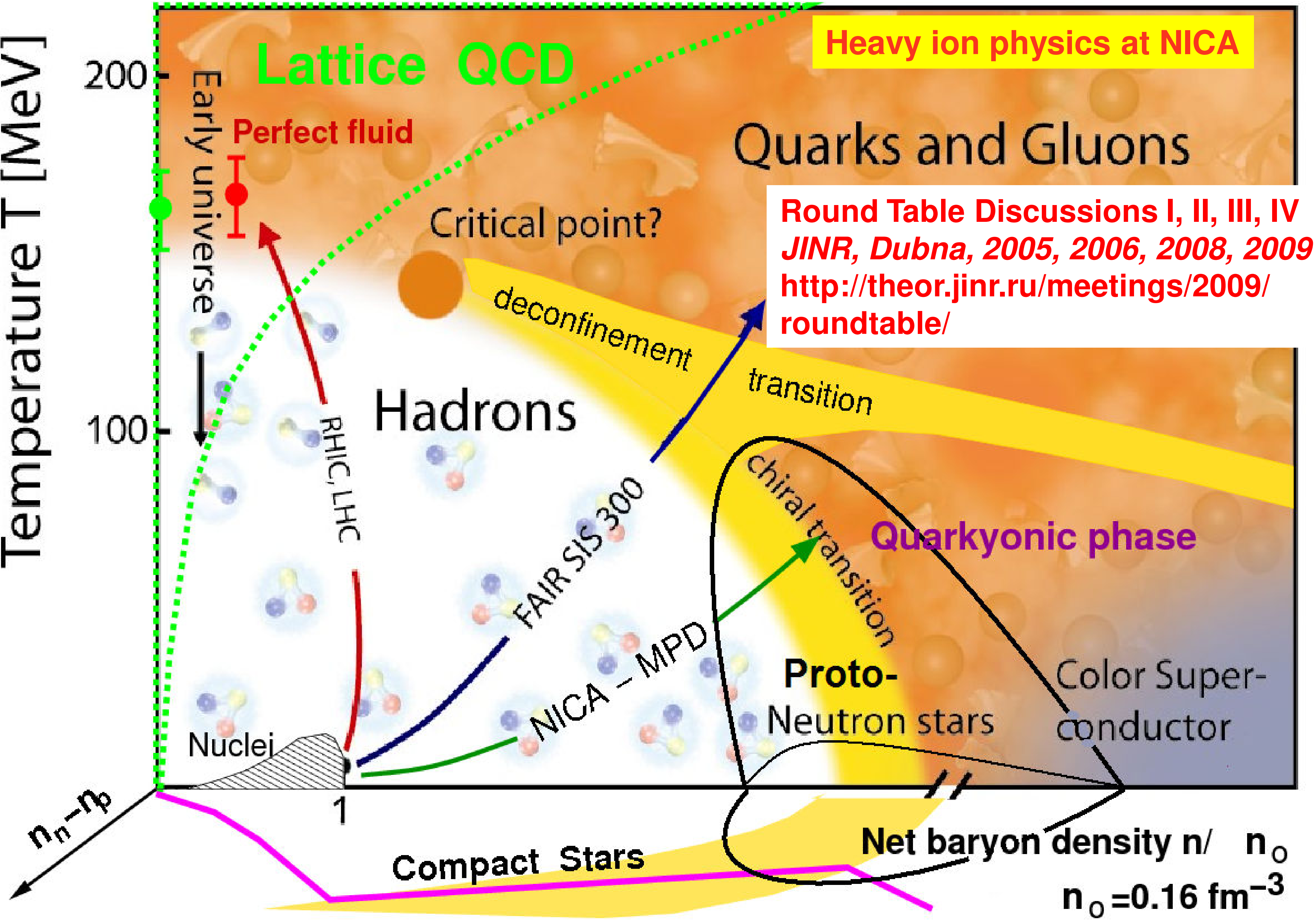
Conceptual Design Report

Dubna 2008

http://nica.jinr.ru

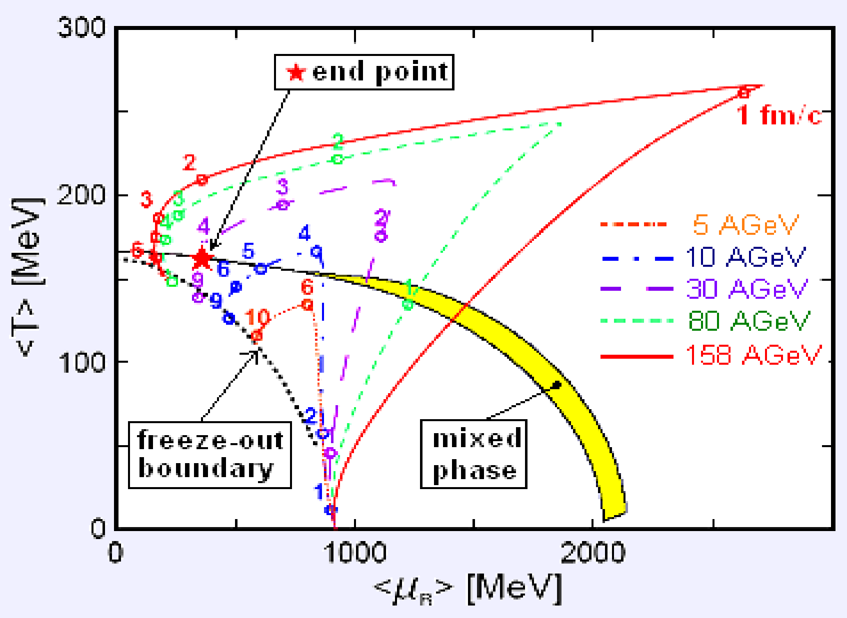
May 2009: the first draft of the NICA TDR is completed

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

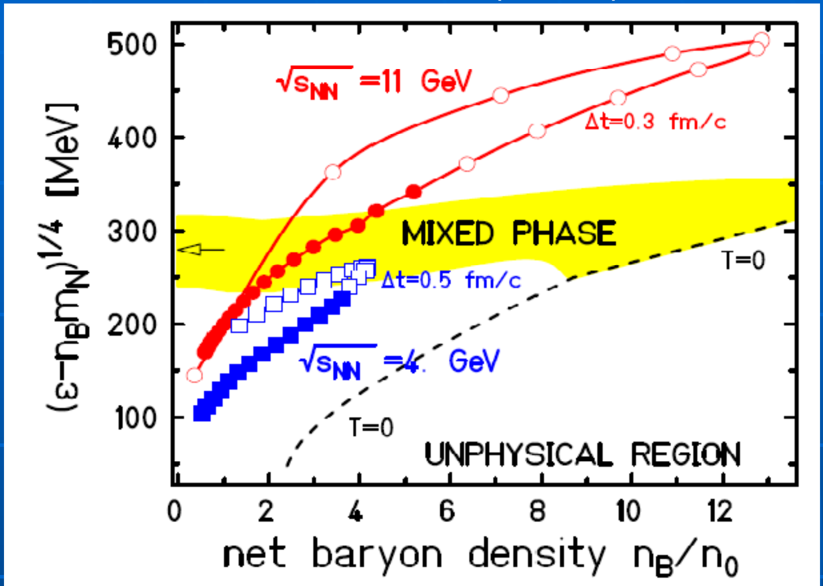


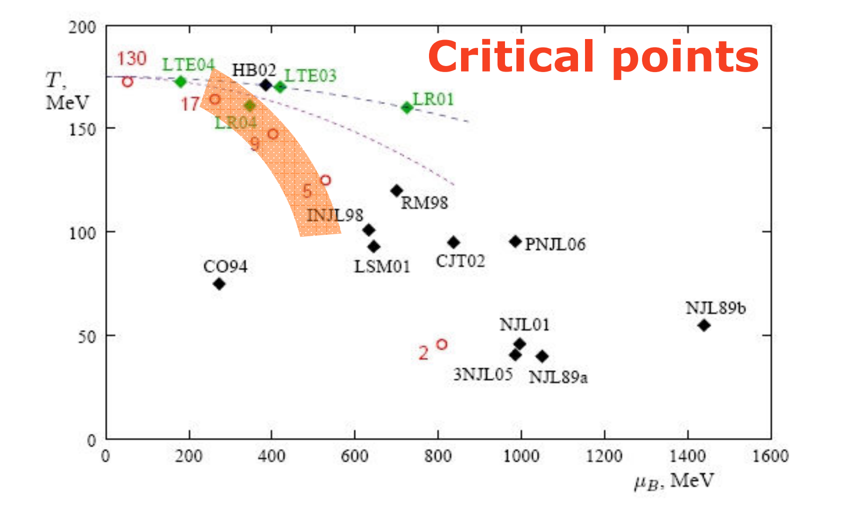
Phase Diagram

Yu.Ivanov, V.Russkikh,V.Toneev, 2005

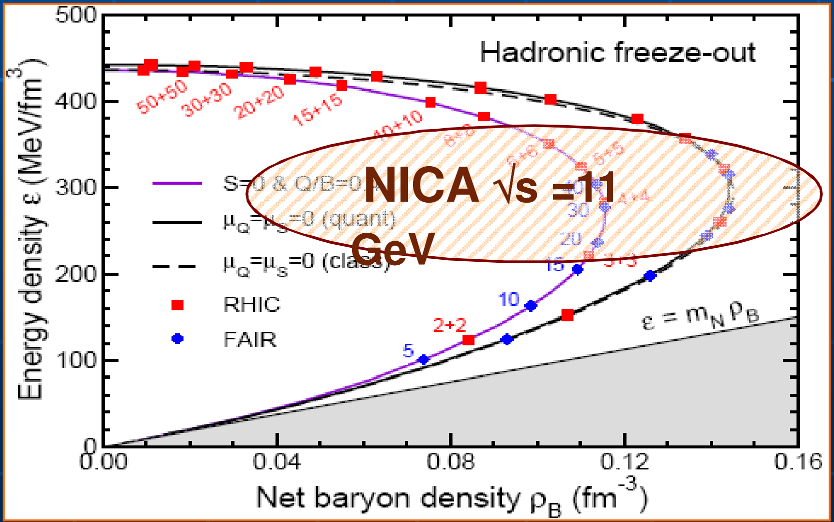


MPD CDR (2009)





M.Stephanov, 2006



J.Randrup, J.Cleymans, 2006

The NICA Physics Program

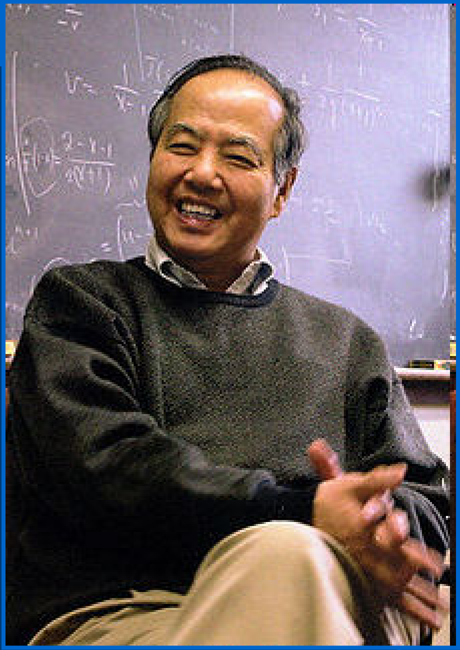
Study of in-medium properties of hadrons and nuclear matter **equation of state** including a search for possible signs of deconfinement and chiral symmetry restoration **phase transitions** and **QCD critical endpoint**

Experimental observables:

Scanning in beam energy and centrality of **excitation functions** for

- ♣ Multiplicity and global characteristics of identified hadrons including (multi)strange particles
- ♣ Fluctuations in multiplicity and transverse momenta
- ♣ Directed and elliptic flows for various indentified hadrons
- ♣ particle correlations
- ♣ Dileptons and photons

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,

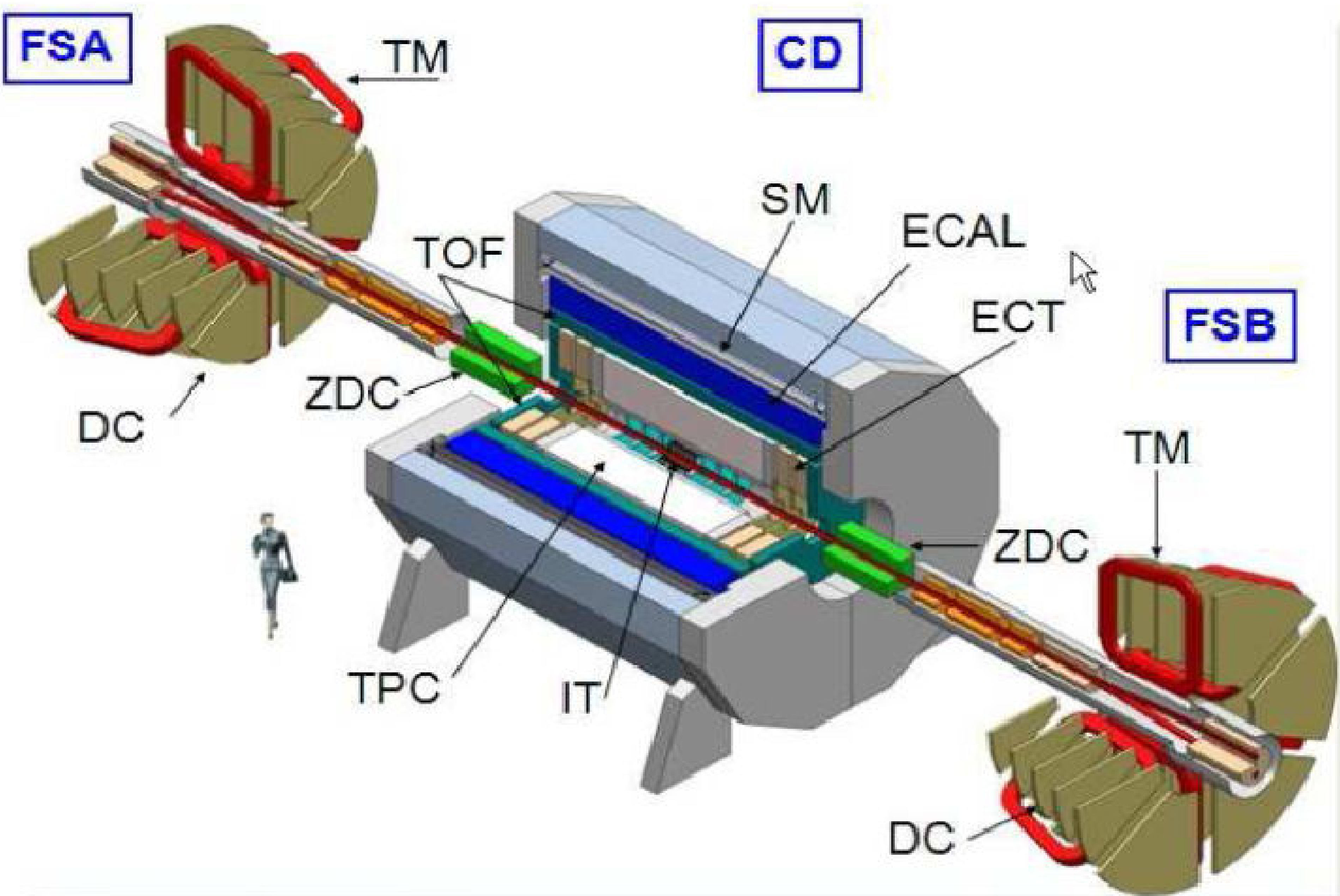
T. D. Lee
--
T. D. Lee
University Professor
Dept. of Physics - MC 5208
Columbia University
New York, NY 10027

Highlight of the Round Table III:

D.Kharzeev on the chiral magnetic effect:

- Quantum anomalies play an important role in the bulk properties of hot QCD matter
- Scale anomaly induces a sharp peak in bulk viscosity at the QCD phase transition
- Axial anomaly and sphalerons may induce an event-by-event P and CP violation
- All of this can be studied at NICA

MPD conceptual design



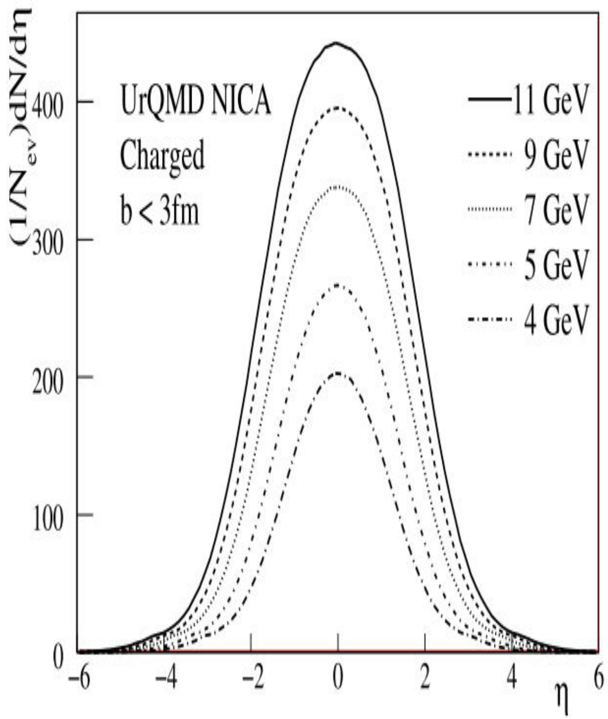


Fig. 1.5: Pseudorapidity distributions of charged particles in central Au + Au collisions ($b < 3$ fm) calculated by UrQMD.

Table 1.1: Calculated by UrQMD the mean particle multiplicitiy in central Au+Au events (impact parameter $b < 3$ fm).

Part.	4 GeV			7 GeV			11 GeV		
		$p > 100$ MeV/c			$p > 100$ MeV/c			$p > 100$ MeV/c	
	4π	$\lvert\eta\rvert < 1$	$\lvert\eta\rvert < 2$	4π	$\lvert\eta\rvert < 1$	$\lvert\eta\rvert < 2$	4π	$\lvert\eta\rvert < 1$	$\lvert\eta\rvert < 2$
charged	428.2	246.8	372.7	870.8	429.9	717.4	1280	554.7	1011
p	170.8	90.9	144.3	162.1	63.01	117.8	156.7	48.92	99.16
n	202	105.4	168.2	180.4	68.21	127.9	174.5	52.92	107.4
π^+	106.9	64.58	94.53	306.4	159.6	259.2	473.9	226.2	385.7
π^-	129.6	78.33	114.6	335.2	174.1	282.9	520.4	237.3	422.2
π^0	120.1	72.3	106.3	337.1	175.0	284.9	512.5	244.8	412.2
K^+	12.0	7.576	11.07	37.9	18.8	32.52	57.35	23.69	46.58
K^-	1.322	0.818	1.22	11.52	6.193	10.15	26.04	11.77	21.62
K^0	12.01	7.65	11.07	38.28	19.0	32.83	56.88	26.18	44.19
Λ	10.31	6.249	9.421	25.64	11.94	21.31	31.15	12.12	23.88
Σ^+	3.419	2.068	3.12	8.011	3.654	6.62	9.231	3.615	7.115
Σ^-	3.994	2.414	3.623	8.802	4.025	7.255	10.23	3.769	7.385
Σ^0	3.198	1.906	2.888	7.853	3.568	6.452	9.385	3.846	6.731
Ξ^-	0.157	0.105	0.15	0.869	0.423	0.736	1.692	0.654	1.346
Ξ^0	0.126	0.077	0.117	0.859	0.415	0.731	1.269	0.615	0.885
Ω^-	0.003	0.002	0.003	0.022	0.011	0.0136	0.038	0.015	0.035

Table 1.2: Properties of the hyperons accessible through their decays into charged hadrons. Multiplicity of the hyperons is calculated by UrQMD for central Au+Au collisions at $\sqrt{s_{NN}} = 7$ GeV.

	Mass (GeV/c^2)	Lifetime $c\tau$ (cm)	Multiplicity	Decay channel	BR(%)	Geometry acceptance (%) $\lvert p\rvert > 0.1$ GeV/c $-1 < y < 1$
Λ	1.116	7.89	39.8	$p + \pi^-$	63.9	16
Ξ^-	1.321	4.91	1.21	$\Lambda + \pi^-$	99.9	8
Ω^-	1.672	2.46	0.03	$\Lambda + K^-$	67.8	5

MPD Collaboration

http://nica.jinr.ru

- Joint Institute for Nuclear Research
- Institute for Nuclear Research Russian Academy of Science
- Bogolyubov Institute of Theoretical Physics, NASUk
- Skobeltsyn Institute of Nuclear Physics of Lomonosov MSU, RF
- Institute of Apllied Physics, Academy of Science Moldova
- …
- *Open for extension …*

A consortium involving GSI, JINR & other centers for IT module development & production is created.

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

The MPD Collaboration:[1]

Kh.U.Abraamyan, S.V.Afanasiev, N.Anfimov, D.Arkhipkin, P.Zh.Aslanyan, V.A.Babkin, S.N.Basylev, D.Blaschke, D.N.Bogoslovsky, I.V.Boguslavski, V.V.Borisov, A.V.Butenko, V.V.Chalyshev, S.P.Chernenko, V.F.Chepurnov, V.F.Chepurnov, G.A.Cheremukhina, I.E.Chirikov-Zorin, D.E.Donetz, K.Davkov, V.Davkov, D.K.Dryablov, D.Drnojan, V.B.Dunin, L.G.Efimov, E.Egorov, D.D.Emeljanov, O.V.Fateev, Yu.I.Fedotov, V.M.Golovatyuk, N.V.Gorbunov, Yu.A.Gornushkin, A.V.Guskov, A.Yu.Isupov, V.N.Jejer, G.D.Kekelidze, V.D.Kekelidze, Yu.T.Kiryushin, V.Kizka, V.I.Kolesnikov, A.D.Kovalenko, R.Lednitsky, A.G.Litvinenko, E.I.Litvinenko, S.P.Lobastov, V.M.Lysan, J.Lukstins, V.M.Lucenko, N.Krahotin, Z.V.Krumshtein, D.T.Madigozhin, A.I.Malakhov, I.N.Meshkov, V.V.Mialkovski, I.I.Migulina, N.A.Molokanova, S.A.Movchan, Yu.A.Murin, G.J.Musulmanbekov, V.A.Nikitin, A.G.Olchevski, V.F.Peresedov, D.V.Peshekhonov, V.D.Peshekhonov, I.A.Polenkevich, Yu.K.Potrebenikov, V.S.Pronskikh, S.V.Razin, O.V.Rogachevskiy, A.B.Sadovsky, Z.Sadygov, A.A.Savenkov, S.V.Sergeev, B.G.Shchinov, A.V.Shabunov, A.O.Sidorin, A.N.Sissakian, I.V.Slepnev, V.M.Slepnev, T.M.Solovjeva, A.S.Sorin, O.V.Teryaev, V.V.Tichomirov, V.D.Toneev, G.V.Trubnikov, I.A.Tyapkin, N.M.Vladimirova, S.V.Volgin, V.I.Yurevich, Yu.V.Zanevsky, A.I.Zinchenko, V.N.Zrjuev, R.Ya.Zulkarneev, Yu.R.Zulkarneeva
Joint Institute for Nuclear Research

V.A.Matveev, M.B.Golubeva, F.F.Guber, A.P.Ivashkin, L.V.Kravchuck, A.B.Kurepin, T.L.Karavicheva, A.I.Maevskaya, A.I.Reshetin
Institute for Nuclear Research, RAS, RF

E.E.Boos, V.L.Korotkikh, I.P.Lokhtin, L.V.Malinina, M.M.Merkin, S.V.Petrushanko, L.I.Sarycheva, A.M.Snigirev, A.G.Voronin
Skobeltsyn Institute of Nuclear Physics Moscow State University

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S.Igolkin, G.Feofilov, V.Zherebchevskiy, V.Lazarev
St.Petersburg State University

G.M.Zinovjev, K.A.Bugaev
Bogolyubov Institute for Theoretical Physics, NAS, Ukraine

K.K.Gudima, M.I.Baznat
Institute of Applied Physics, AS, Moldova

I.Stamenov, I.Geshkov
Institute for Nuclear Reseach & Nuclear Energy BAS, Sofia, Bulgaria

B.V.Gringov
Institute for Scintillation Materials, Kharkov, Ukraine

V.N.Borshchov, O.M.Listratenko, M.A.Protsenko, I.T.Tymchuk
State Enterprise Scientific & Technology Research Institute for Apparatus construction, Kharkov, Ukraine

N.M.Shumeiko, F.Zazulia
Particle Physics Center of Belarusian State University

Signed MoU with GSI in July 2008

Spin Physics at NICA

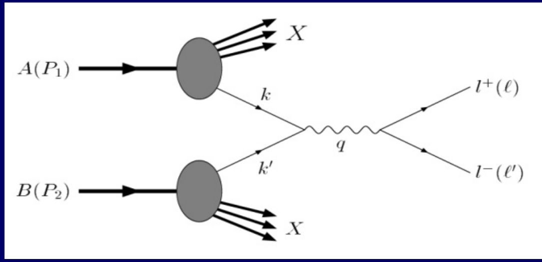
EMC, 1987 $\Delta\Sigma = 0.12 \pm 0.17$

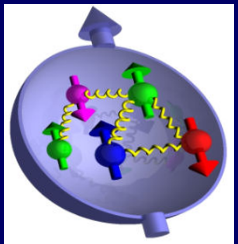
Polarization data has often been the graveyard for fashionable theories. If theorists had their way they might well ban such measurements altogether out of self-protection.

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*



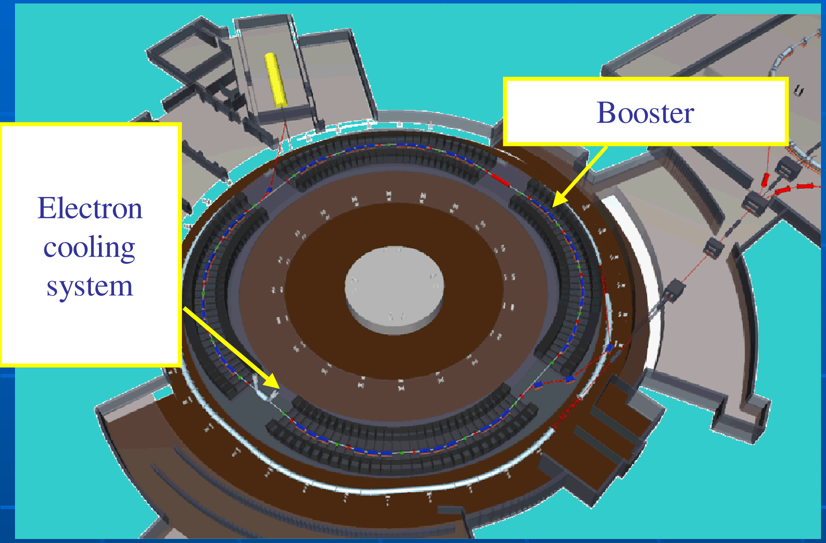


Experiments on DY measurements

Experiment	Status	Remarks
E615	Finished	Only unpolarized DY
NA10	Finished	Only unpolarized DY
E886	Running	Only unpolarized DY
RHIC	Running	Detector upgrade for DY measurements (collider)
PAX	Plan > 2016	Problem with $\bar{p}$ polarization (collider)
COMPASS	Plan > 2010	Only valence PDFs
J-PARC	Plan > 2011	low s (60-100 GeV^2), only unpolarized proton beam
SPASCHARM	Plan?	s ~ 140 GeV^2 for unpolarized proton beam
NICA	Plan 2015	s ~ 670 GeV^2 for polarized proton beams, high luminosity (collider)

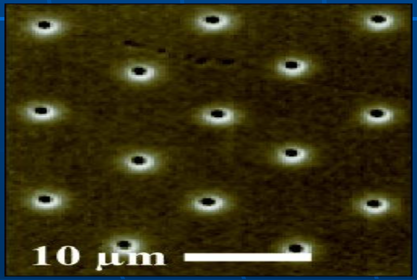
Applied research at NICA

Booster-sinhrotron appliction to nanostructures creations:

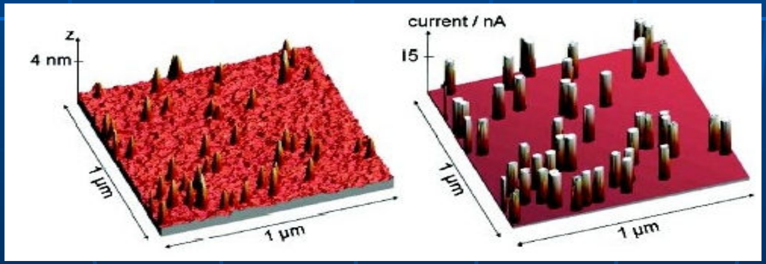


Design and parameters of booster, including wide accessible energy range, possibility of the electron cooling, allow to form dense and sharp ion beams. System of slow extraction provides slow, prolongated in time ion extraction to the target with space scanning of ions on the target surface and guaranty **high controllability** of experimental conditions.

Ion-track technologies:



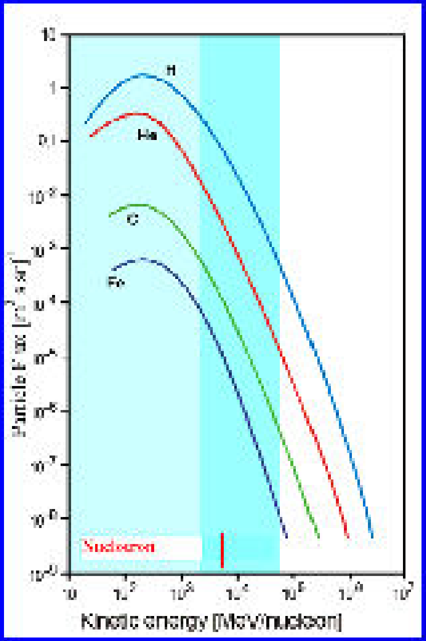
Ion tracks in a polymer matrix (GSI, Darmstadt)



Topography and current of a diamond-like carbon (DLC) film.The 50 nm thick DLC film was irradiated with 1 GeV Uranium ions.

Production of nanowires, filters, nanotransistors, ...

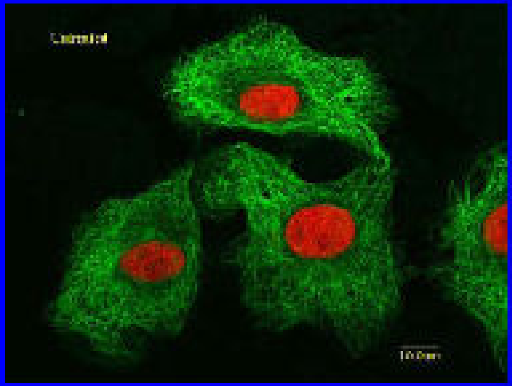
NICA and Space Radiobiology

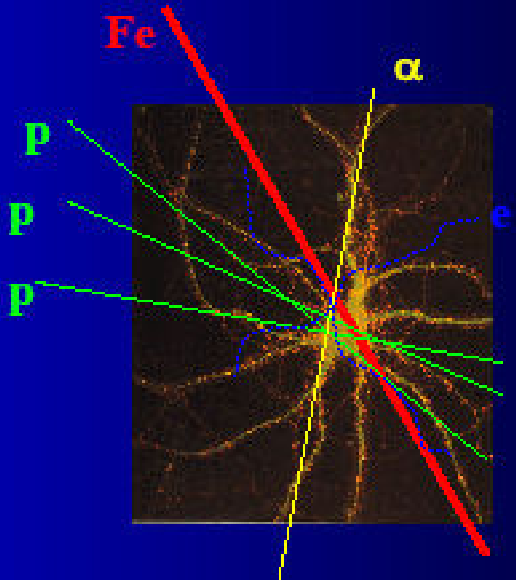


Energetic spectrum of Galactic heavy ions

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.**





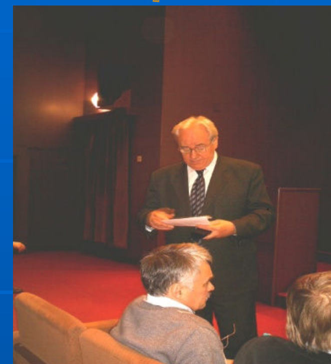
Concluding remarks

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/



IHEP-JINR seminar at Protvino, 14.02.08

МЕМОРАНДУМ
Совместного семинара ИТЭФ-ОИЯИ
Институт теоретической и экспериментальной физики
27 мая 2009 года, г. Москва

Участники семинара заслушали доклады:
А.Н. Сисакян "Ускорительный комплекс NICA: статус и перспективы".
Б.Ю. Шарков "Новые возможности ускорителей для исследования вещества экстремальных условиях".
И.Н. Мешков "Коллайдеры тяжёлых ионов RHIC и NICA: статус и перспективы".
В.Д. Тонеев "Физика тяжёлых ионов на ускорительном комплексе NICA".

Отмечены:
1) актуальность и возрастающая привлекательность исследований тяжелоионных столкновений в диапазоне энергий $\sqrt{s_{NN}} \sim 4 - 11$ ГэВ для фундаментальных проблем поиска новых состояний ядерной материи и изучения процессов экстремально высоких плотностей;
2) прогресс в развитии проекта NICA, получившего широкую международную известность и высокую оценку авторитетных экспертов мирового уровня;
3) заинтересованность специалистов ИТЭФ в активном участии в совместных с ОИЯИ работах по проекту NICA;
4) необходимость более тесной кооперации в решении проблем, представляющих взаимный интерес, включая организацию ассоциации (консорциума, сообщества) по исследованию экстремальных состояний вещества и фазовых превращений в ионных столкновениях.

Соруководители семинара:

А.Н.Сисакян академик РАН	В.И.Захаров профессор

Участники семинара:

Б.Ю.Шарков член-корреспондент РАН	И.Н.Мешков член-корреспондент РАН	А.Б.Кайдалов член-корреспондент РАН

А.С.Сорин профессор	В.Д.Тонеев профессор	А.Д.Коваленко профессор	Г.В.Трубников кфмн

ITEP-JINR seminar at ITEP, 27.05.09

MEMORANDUM

NICA
JINR - DUBNA

Round Table Discussions I, II, III, IV
JINR, Dubna, 2005, 2006, 2008, 2009

Решение
Общемосковского семинара по релятивистской ядерной физике

27 марта 2008 года
Институт Ядерных Исследований РАН

Участники семинара "Проект NICA (тяжелоионный коллайдер: концепции, планы реализации и перспективы совместных работ)" заслушав доклады, представленные разработчиками Проекта NICA/MPD (ОИЯИ):
1. А.Н. Сисакян "Статус проекта NICA/MPD".
2. А.Н. Сисакян, А.С. Сорин "Программа физических исследований на ускорительном комплексе NICA".
3. И.Н. Мешков "Концептуальный проект ускорительного комплекса NICA".
4. В.Д. Кекелидзе "Концептуальный проект многоцелевого детектора MPD".

и обсудив цели и содержание проекта, а также перспективы его осуществления, пришли к следующему заключению.

1. Физическая проблема, инициировавшая разработку Проекта, является одной из наиболее важных среди фундаментальных проблем физики микромира и начальных этапов эволюции Вселенной.

2. Представленные на семинаре концептуальные проекты NICA и MPD выполнены на современном уровне с привлечением передовых технологий и использованием оригинальных идей, предложенных и развитых в России.

3. Осуществление Проекта на базе лабораторий ОИЯИ представляется вполне реальным, а представленные планы работ - выполнимыми.

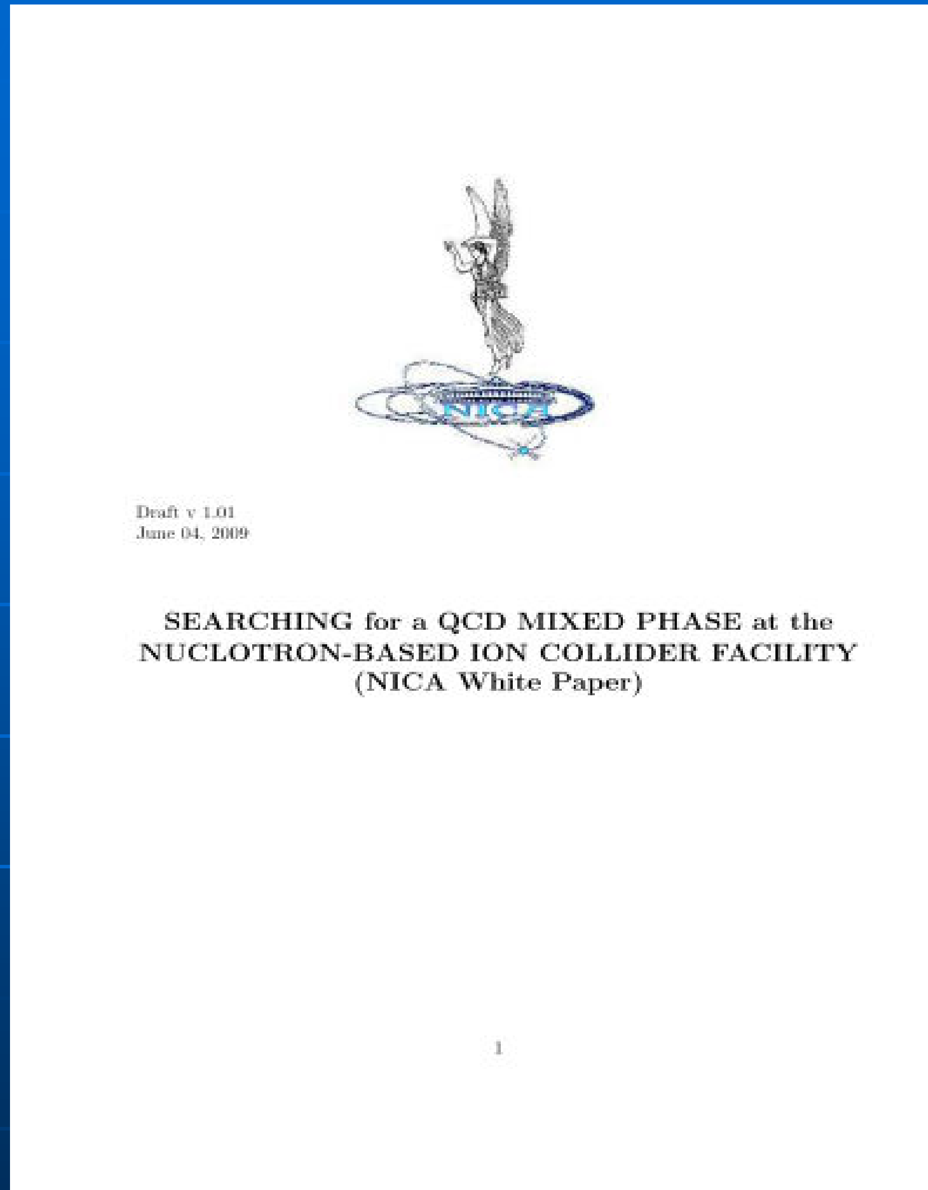
4. Для успешного и быстрого выполнения Проекта целесообразно создание широкой Всероссийской и международной коллаборации.

5. Институты России располагают необходимым научным и инженерно-техническим потенциалом.

6. Успешная реализация Проекта позволит всем участникам Проекта занять лидирующие позиции в физике высоких энергий и войти в число самых передовых исследовательских центров мира.

В.А.Матвеев Директор ИЯИ РАН академик РАН	А.Н.Тавхелидзе академик РАН	Б.Ю.Шарков Директор ИТЭФ чл.-корр. РАН
А.Н.Лебедев чл.-корр. РАН	В. .Рубаков академик РАН	

All Moscow-JINR seminar at INR, 27.03.08


Draft v 1.01
June 04, 2009

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

1

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

NICA White Paper

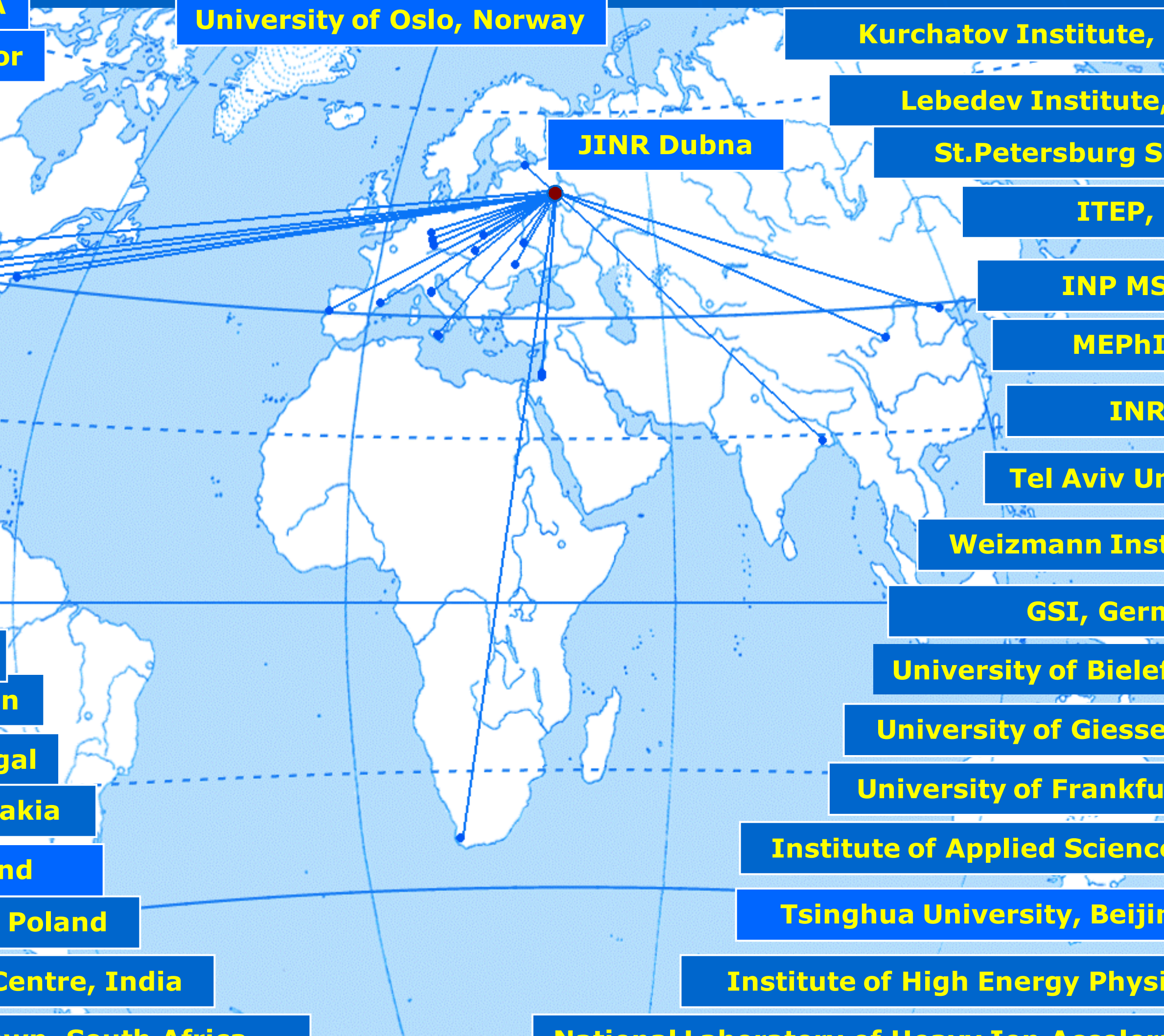
SEARCHING for a QCD MIXED PHASE at the NUCLOTRON-BASED ION COLLIDER FACILITY

In particular, NICA White Paper should help clarifying 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

Round Table IV and the NICA White Paper

85 authors *from* **39 scientific centers** *in* **16 Countries (8 JINR members)**



- Arizona State University, USA
- Los Alamos National Laborator
- University of Illinois, USA
- Wayne SU, USA
- LBNL, USA
- BNL, USA
- Ohio SU, USA
- BITP, Ukraine
- INFN, Italy
- SISSA, Italy
- University of Catania, Italy
- University of Trento, Italy
- University of Florence, Italy
- University of Barselona, Spain
- University of Coimbra, Portugal
- Mateja Bela University, Slovakia
- Wroclav University, Poland
- Jan Kochanovski University, Poland
- Variable Energy Cyclotron Centre, India
- University of Cape Town, South Africa
- University of Oslo, Norway
- Kurchatov Institute, Russia
- Lebedev Institute, Russia
- St.Petersburg SU, Russia
- ITEP, Russia
- INP MSU, Russia
- MEPhI, Russia
- INR, Russia
- Tel Aviv University, Israel
- Weizmann Institute, Israel
- GSI, Germany
- University of Bielefeld, Germany
- University of Giessen, Germany
- University of Frankfurt, Germany
- Institute of Applied Science, Moldova
- Tsinghua University, Beijing, China
- Institute of High Energy Physics, China
- National Laboratory of Heavy Ion Accelerator, China

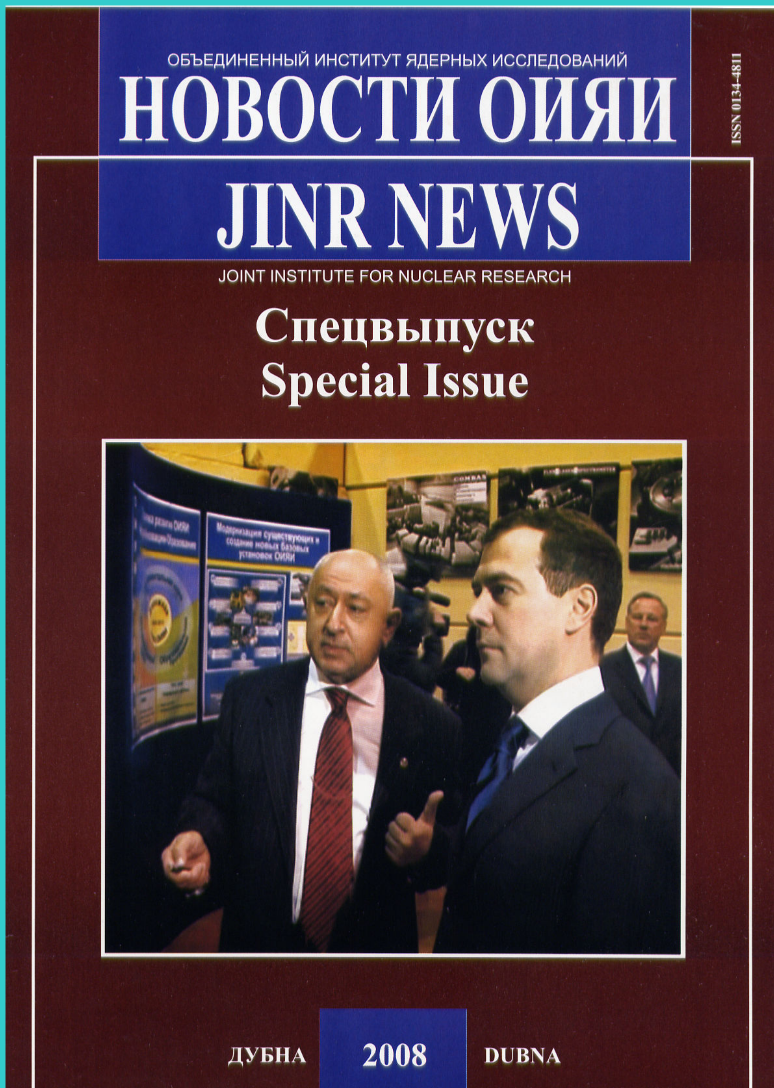
http://theor.jinr.ru/twiki-cgi/view/NICA/WebHome

International Coordinating Committee meeting on the NICA Project

Nuclotron-M Machine Advisory Committee and Honorary guests

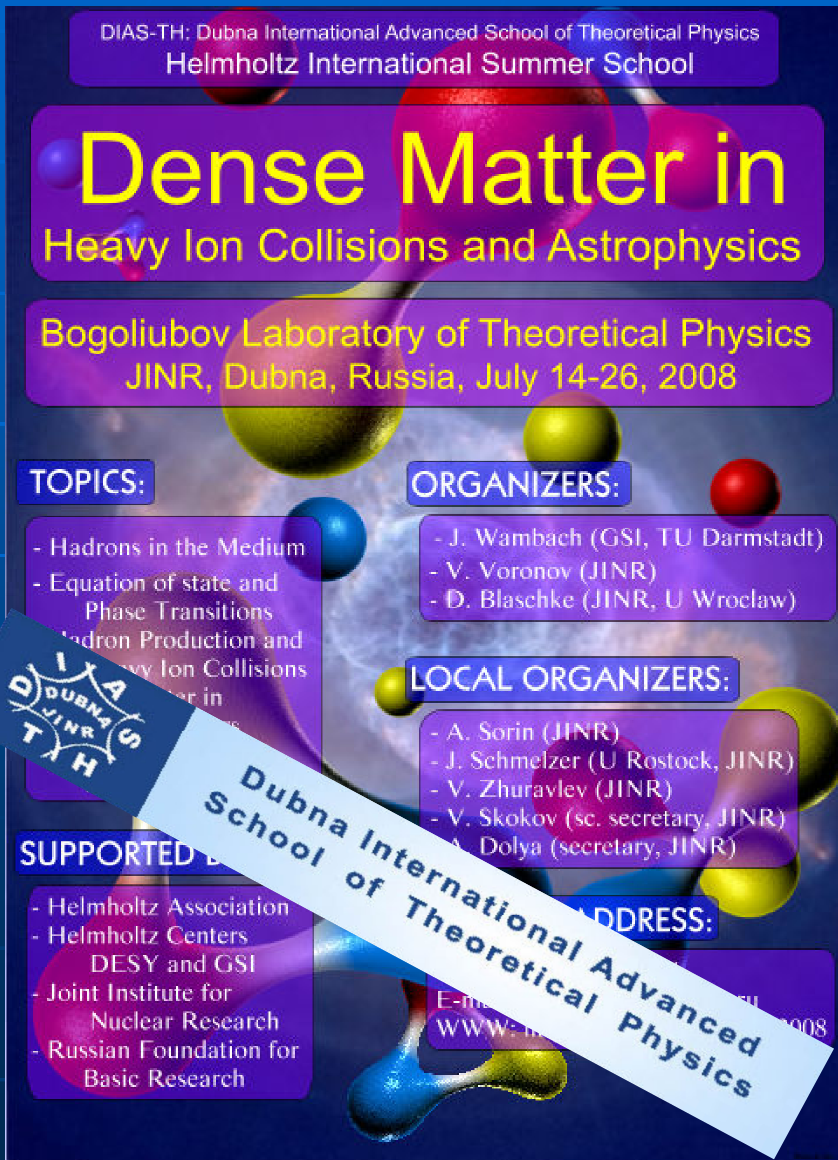
Visit of the GSI director Prof. Stoecker to JINR

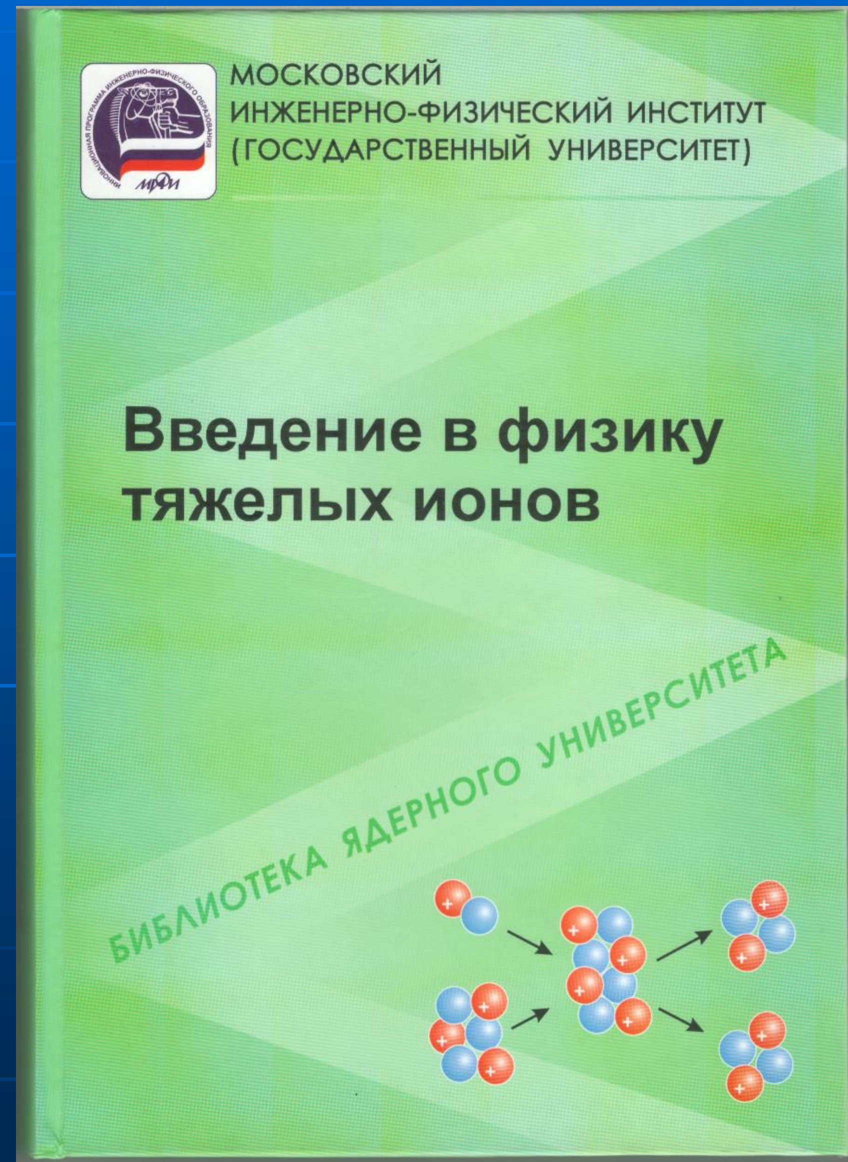
President D. Medvedev visits JINR on 18 April 2008



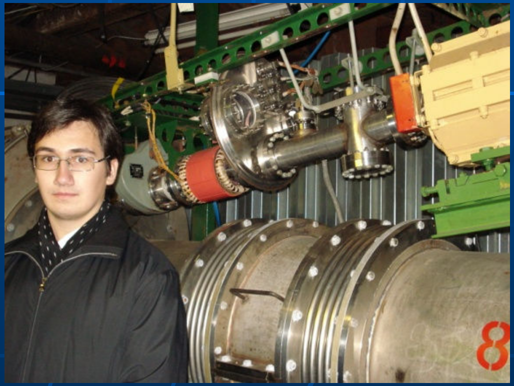
On 18 April, President-elect of the Russian Federation Dmitry Medvedev chaired in Dubna a session of the Presidium of the State Council which discussed the issue "Development of the National Innovation System in the Russian Federation".

EDUCATIONAL PROGRAMS IN HEAVY ION PHYSICS





Prospect: Students and NICA



Welcome to the
School
"Dense matter in HIC", August 16 -22, 2010
and
Conference
"Critical Point and Onset of Deconfinement"
August 23 – 29, 2010
JINR, Dubna
http://theor.jinr.ru/meetings/2010/

Welcome to the collaboration!

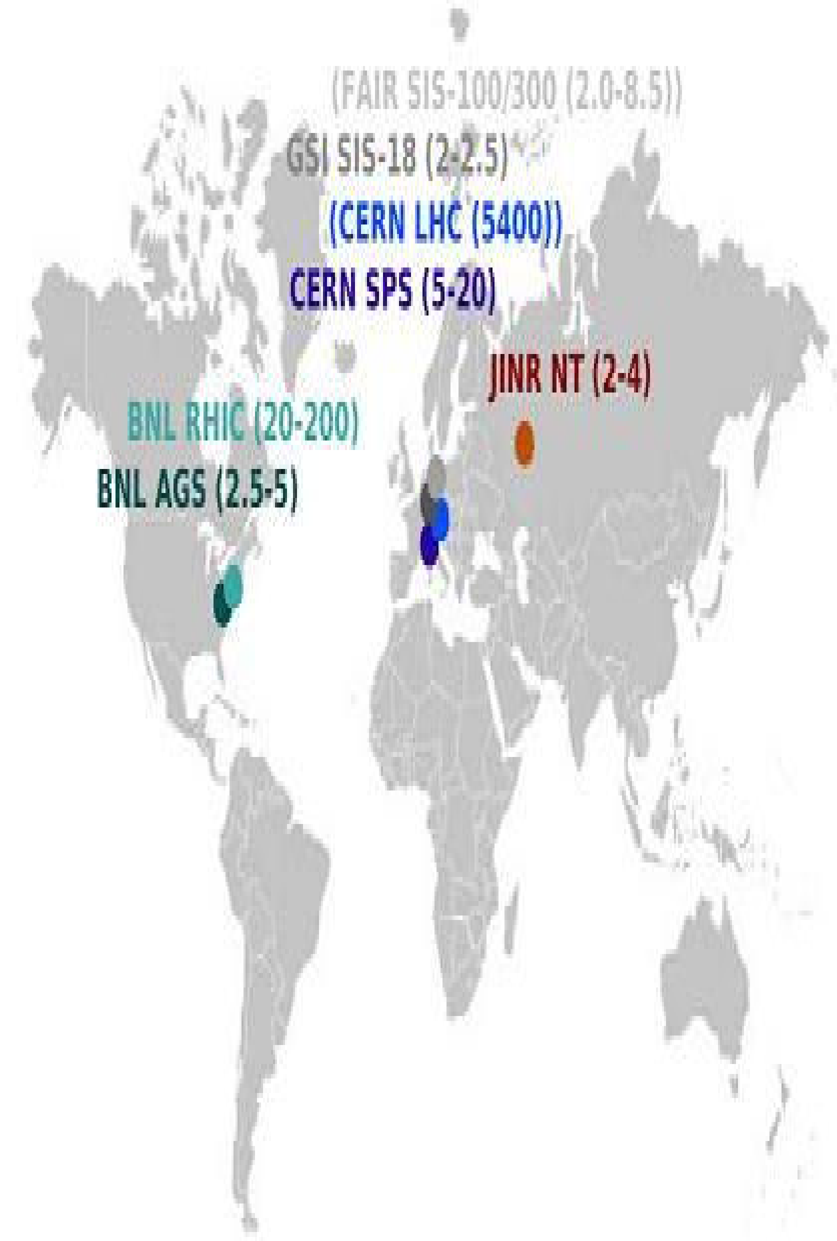
JOINT INSTITUTE FOR NUCLEAR RESEARCH

JINR

NICA

Thank you for attention!

Heavy Ion Accelerators



Relativistic Heavy Ion Facilities from Synchrophasotron and AGS to NICA and FAIR

Over the last 30 years a lot of efforts have been made to provide the conditions for searching for new states of strongly interacting matter under extreme conditions.

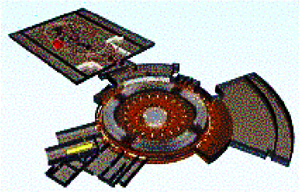
Synchrophasotron: E_{lab} ~ 4.2 AGeV ($\sqrt{s_{NN}}$ = 3GeV)
1971 - 1999, pioneering experiments in the field of relativistic nuclear physics.

AGS: E_{lab} ~ 11 AGeV ($\sqrt{s_{NN}}$ = 5GeV)
1986 – 1992, study of compressed baryonic matter.

SPS: E_{lab} ~ 158 AGeV ($\sqrt{s_{NN}}$ =18 GeV)
1986- up to now,
study of compressed baryonic matter.

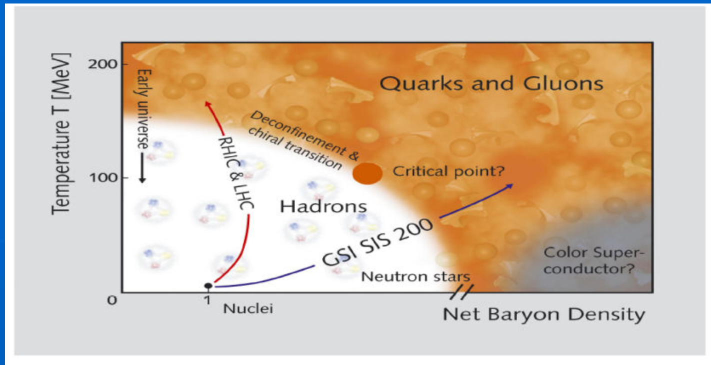
RHIC: $\sqrt{s_{NN}}$ = 200 GeV (E_{lab} ~ 80000 AGeV)
1996 - up to now.

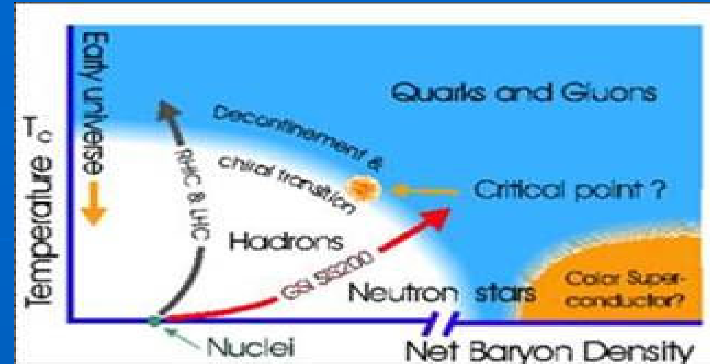
LHC: $\sqrt{s_{NN}}$ = 5600 AGeV (E_{lab} ~ $6.3\cdot10^7$ AGeV)
2009 - planned

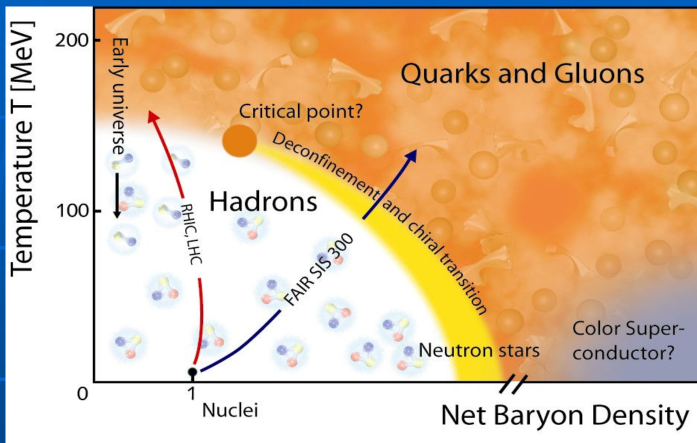


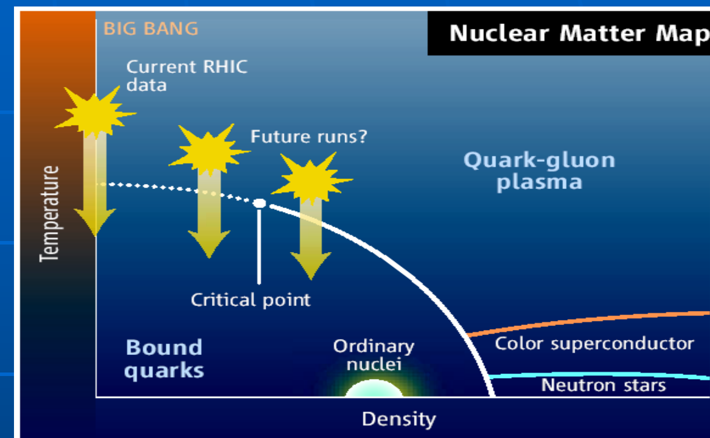
SIS 300: (FAIR GSI) E_{lab} **~40 AGeV**
($\sqrt{s_{NN}}$ = 8.5 GeV),
full performance will be reached in 2015,
study of compressed baryonic matter.

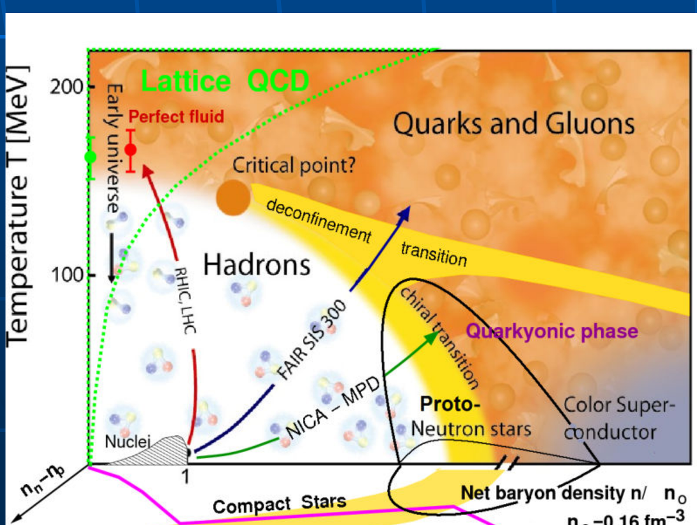
NICA: $\sqrt{s_{NN}}$: **~ 11GeV (E_{lab}~ 60AGeV)**
full performance will be reached in **2015**
search for the mixed phase of strongly interacting matter.

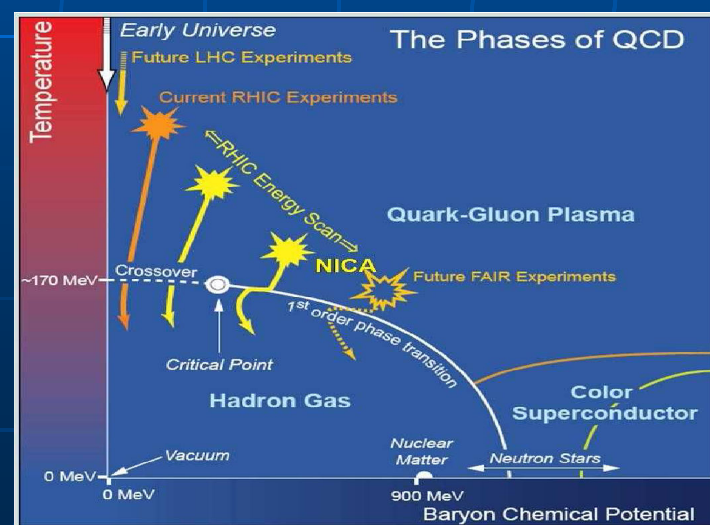

Temperature T [MeV]
200
100
0
1
Early universe
RHIC & LHC
Deconfinement & chiral transition
Quarks and Gluons
Critical point?
Hadrons
GSI SIS 200
Neutron stars
Color Super-conductor?
Nuclei
Net Baryon Density


Temperature
Early universe
RHIC & LHC
Deconfinement & chiral transition
Quarks and Gluons
Critical point ?
Hadrons
GSI SIS200
Neutron stars
Color Super-conductor?
Nuclei
Net Baryon Density


Temperature T [MeV]
200
100
0
1
Early universe
RHIC,LHC
Quarks and Gluons
Critical point?
Deconfinement and chiral transition
Hadrons
FAIR SIS 300
Neutron stars
Color Super-conductor?
Nuclei
Net Baryon Density


BIG BANG
Nuclear Matter Map
Current RHIC data
Future runs?
Quark-gluon plasma
Temperature
Critical point
Bound quarks
Ordinary nuclei
Color superconductor
Neutron stars
Density


Temperature T [MeV]
200
100
1
Lattice QCD
Perfect fluid
Early universe
Quarks and Gluons
Critical point?
deconfinement
transition
Hadrons
RHIC,LHC
FAIR SIS 300
chiral transition
Quarkyonic phase
NICA – MPD
Proto-Neutron stars
Color Super-conductor
Nuclei
Compact Stars
Net baryon density n/ n_0
n_0=0.16 fm^{-3}


Temperature
Early Universe
The Phases of QCD
Future LHC Experiments
Current RHIC Experiments
⇐RHIC Energy Scan⇒
Quark-Gluon Plasma
NICA
Future FAIR Experiments
~170 MeV
Crossover
1st order phase transition
Critical Point
Hadron Gas
Color Superconductor
Vacuum
Nuclear Matter
Neutron Stars
0 MeV
0 MeV
900 MeV
Baryon Chemical Potential