Status of NICA Project

Nuclotron-based Ion Collider Facility

I. Meshkov, G. Trubnikov
for NICA Collaboration

BNL
November 5, 2009
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“The physics case” and goals of the NICA project
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4. NICA project status and nearest plans
Conclusion
Introduction: Relativistic nuclear physics today & “the physics case” of NICA

Lattice QCD

Quarks and Gluons

Hadrons

Critical point?

Perfect fluid

Transition

deconfinement

Proto-stars

Neutron stars

Color Superconductor

n/n_{nuclear} (n_{nuclear} = 0.16 fm^{-3})

Temperature T [MeV]

Early universe

RHIC, LHC

NICA - MPD

CritRHIC (2009)

FAIR-SIS 300

Compact Stars

n_{nuclear} = 0.16 fm^{-3}
The NICA Project goals formulated in NICA CDR are the following:

1a) Heavy ion colliding beams $^{197}\text{Au}^{79+} \times ^{197}\text{Au}^{79+}$ at
\[ \sqrt{s_{NN}} = 4 \div 11 \text{ GeV (1 \div 4.5 GeV/u ion kinetic energy )} \]
at
\[ L_{\text{average}} = 1 \cdot 10^{27} \text{ cm}^{-2} \cdot \text{s}^{-1} \] (at $\sqrt{s_{NN}} = 9 \text{ GeV}$)

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

2) Polarized beams of protons and deuterons:
\[ p^{\uparrow}p^{\uparrow} \sqrt{s_{NN}} = 12 \div 25 \text{ GeV (5 \div 12.6 GeV kinetic energy )} \]
\[ d^{\uparrow}d^{\uparrow} \sqrt{s_{NN}} = 4 \div 13.8 \text{ GeV (2 \div 5.9 GeV/u ion kinetic energy )} \]
1. NICA scheme & layout

- Synchrophasotron yoke
- Existing beam lines (Fixed target exp-s)
- Booster
- Nuclotron
- Beam transfer line
- Collider $C = 251$ m
- MPD
- Krion-6T & HILac
- "Old" linac

Spin Physics Detector (SPD)

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1. NICA scheme & layout (Contnd)

- “Old” Linac LU-20
- KRION + “New” HILAC
- Booster
- Nuclotron
- Collider
- SPD
- MPD
- Beam dump

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2. Heavy ions in NICA

2.1. Operation regime and parameters

**Injector (45 Tm)**

- **2x10^9** ions/pulse of $^{197}$Au$^{32+}$ at energy of 6.2 MeV/u

**Collider (45 Tm)**

- Storage of 17 (20) bunches x 1.1 x 10^9 ions per ring at 1 ÷ 4.5 GeV/u, electron and/or stochastic cooling

**Nuclotron (45 Tm)**

- Injection of one bunch of 1.1 x 10^9 ions, acceleration up to 1 ÷ 4.5 GeV/u max.

**Booster (25 Tm)**

- 1(2-3) single-turn injection, storage of 2 (4-6) x 10^9, acceleration up to 100 MeV/u, electron cooling, acceleration up to 600 MeV/u

**Stripping (80%)** $^{197}$Au$^{32+}$ $\Rightarrow$ $^{197}$Au$^{79+}$

**Bunch compression (RF phase jump)**

**Two superconducting collider rings**

**Bunch compression (RF phase jump)**

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## 2. Heavy ions in NICA (Contnd)

### 2.1. Operation regime and parameters

**Bunch parameters dynamics in the injection chain**

<table>
<thead>
<tr>
<th>Stage</th>
<th>$E$ MeV/u</th>
<th>$\varepsilon_{\text{unnorm}}$ π-mm-mrad</th>
<th>$\Delta p/p$</th>
<th>$I_{\text{bunch}}$ $\mu$A</th>
<th>Intensity loss,%</th>
<th>$N_{\text{extr}}$ = 1E9</th>
<th>Space charge $\Delta Q$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Injection (after stripping)</td>
<td>594</td>
<td>0.25</td>
<td>3.4E-4</td>
<td>3.1</td>
<td>&lt;20</td>
<td>0.051</td>
<td>0.0075</td>
</tr>
<tr>
<td>After cooling (h=1)</td>
<td>100</td>
<td>2.45</td>
<td>3.8E-4</td>
<td>7.17</td>
<td>&lt;10</td>
<td>0.016</td>
<td></td>
</tr>
<tr>
<td>At extraction</td>
<td>600</td>
<td>0.89</td>
<td>3.2E-4</td>
<td>3.1</td>
<td>&lt;20</td>
<td>0.0085</td>
<td></td>
</tr>
<tr>
<td>At extraction</td>
<td>3500</td>
<td>0.25</td>
<td>1.0E-3</td>
<td>0.5</td>
<td>10</td>
<td>0.03</td>
<td>$\Sigma \text{Loss} = 40%$</td>
</tr>
</tbody>
</table>

Bulk loss = 40%

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2. Heavy ions in NICA (Contnd)

2.1. Operation regime and parameters

Bunch compression in Nuclotron

Phase space portraits of the bunch

Bunch rotation by “RF amplitude jump” $15 \Rightarrow 120 \text{ kV}$

$E - E_0$, 2 GeV/div

$\theta$, 10 deg./div

A. Eliseev

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2. Heavy ions in NICA (Contd)

2.1. Operation regime and parameters

Bunch compression in Nuclotron

Phase space portraits of the bunch (RF “phase jump” $\Delta \phi = 180^0$)

- $\Delta E_{r.m.s.}$ 200 MeV/div
- $\Delta \theta_{r.m.s.}$ 5 deg./div
- $\epsilon_{r.m.s.}$ 0.5 eV⋅sec/div

$\theta$, 50 deg./div

time, 0.1 sec/div.

A. Eliseev

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2. Heavy ions in NICA (Contd)

2.1. Operation regime and parameters

Time Table of The Storage Process

- Booster magnetic field
- Nuclotron magnetic field

- 34 injection cycles to Collider rings of $1 \cdot 10^9$ ions $^{197}\text{Au}^{79+}$ per cycle
- $1.7 \cdot 10^{10}$ ions/ring

- 1 (2-3) injection cycles, electron cooling (?)
- Extraction, stripping to $^{197}\text{Au}^{79+}$
- Bunch compression, extraction
- Injection

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2. Heavy ions in NICA (Contnd)

2.2. Collider

I.Meshkov, O.Kozlov, V.Mikhailov, A.Sidorin, A.Smirnov, N.Topilin

E_cooler, Spin rotator, Beam dump, Upper ring, SPD, Long. kicker, Injection channels, 10 m, Beam Dump, x, y, long, S_Cool PU

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2. Heavy ions in NICA (Contnd)

2.2. Collider (Contnd)

General Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ring circumference, [m]</td>
<td>251.52</td>
</tr>
<tr>
<td>$B_ρ$ max [ T⋅m ]</td>
<td>45.0</td>
</tr>
<tr>
<td>Ion kinetic energy ($Au^{79+}$), [GeV/u]</td>
<td>1.0 ÷ 4.56</td>
</tr>
<tr>
<td>Dipole field (max), [ T ]</td>
<td>4.0</td>
</tr>
<tr>
<td>Quad gradient (max), [ T/m ]</td>
<td>29.0</td>
</tr>
<tr>
<td>Number of dipoles / length</td>
<td>24 / 3.0 m</td>
</tr>
<tr>
<td>Number of vertical dipoles per ring</td>
<td>2 x 4</td>
</tr>
<tr>
<td>Number of quads / length</td>
<td>32 / 0.4 m</td>
</tr>
<tr>
<td>Long straight sections: number / length</td>
<td>2 x 48.0 m</td>
</tr>
<tr>
<td>Short straight sections: number / length</td>
<td>4 x 8.8 m</td>
</tr>
</tbody>
</table>

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### General parameters (Contnd)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta x_{max} / \beta y_{max}$ in FODO period, m</td>
<td>16.8 / 15.2</td>
</tr>
<tr>
<td>$Dx_{max} / Dy_{max}$ in FODO period, m</td>
<td>5.9 / 0.2</td>
</tr>
<tr>
<td>$\beta x_{min} / \beta y_{min}$ in IP, m</td>
<td>0.5 / 0.5</td>
</tr>
<tr>
<td>$Dx / Dy$ in IP, m</td>
<td>0.0 / 0.0</td>
</tr>
<tr>
<td>Free space at IP (for detector)</td>
<td>9 m</td>
</tr>
<tr>
<td>Beam crossing angle at IP</td>
<td>0</td>
</tr>
<tr>
<td>Betatron tunes $Q_x / Q_y$</td>
<td>5.26 / 5.17</td>
</tr>
<tr>
<td>Chromaticity $Q'x / Q'y$</td>
<td>-12.22 / -11.85</td>
</tr>
<tr>
<td>Transition energy, $\gamma_{tr} / E_{tr}$</td>
<td>4.95 / 3.012 GeV/u</td>
</tr>
<tr>
<td>RF system harmonics amplitude, [kV]</td>
<td>102 / 100</td>
</tr>
<tr>
<td>Vacuum, [ pTorr ]</td>
<td>100 / 10</td>
</tr>
</tbody>
</table>
##Collider beam parameters and luminosity

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value 1.0</th>
<th>Value 3.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy, GeV/u</td>
<td>1.0</td>
<td>3.5</td>
</tr>
<tr>
<td>Ion number per bunch</td>
<td>1E9</td>
<td>1E9</td>
</tr>
<tr>
<td>Number of bunches per ring</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>Rms unnormalized beam emittance, π·mm mrad</td>
<td>3.8</td>
<td>0.25</td>
</tr>
<tr>
<td>Rms momentum spread</td>
<td>1E-3</td>
<td>1E-3</td>
</tr>
<tr>
<td>Rms bunch length, m</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td><strong>Luminosity per one IP, cm⁻²·s⁻¹</strong></td>
<td><strong>0.75E26</strong></td>
<td><strong>1.1E27</strong></td>
</tr>
<tr>
<td>Incoherent tune shift $\Delta Q_{\text{beam}}$</td>
<td>0.056</td>
<td>0.047</td>
</tr>
<tr>
<td>Beam-beam parameter $\xi$</td>
<td>0.0026</td>
<td>0.0051</td>
</tr>
<tr>
<td><strong>IBS growth time, s</strong></td>
<td><strong>650</strong></td>
<td><strong>50</strong></td>
</tr>
</tbody>
</table>
2. Heavy ions in NICA (Contnd)

2.2. Collider (Contnd)

Two injection schemes are considered:

1) bunch by bunch injection, 17 bunches:
- bunch number is limited by kicker pulse duration,
- bunch compression in Nuclotron is required (!)
- Electron and/or stochastic cooling is used for luminosity preservation.

2) Injection and storage with barrier bucket technique and cooling of a coasting (!) beam, 20 bunches,
- bunch number is limited by interbunch space in IP straight section,
- bunch compression in Nuclotron is NOT required (!)
- Electron and/or stochastic cooling for storage and luminosity preservation, bunch formation after storage are required.

Under development by Prof. T.Katayama (retired from Tokyo Univ.)
3. Heavy ions in NICA (Contnd) 3.2. Collider (Contnd)

**Barrier Bucket Method**

Ion trajectory in the phase space ($\Delta p$, $\varphi$)

In reality RF voltage pulses can be (and are actually) of nonrectangular shape

The first proposal: Fermilab, J. Griffin et.al., IEEE Trans. on Nuclear Science, v.NS30 No.4, 3502 (1983)

The particle storage with barrier buckets method was tested at ESR (GSI) with electron cooling (2008).

**NICA:** $T_{\text{revolution}} = 0.85 \div 0.96 \, \mu\text{s}$, $V_{BB} \leq 16 \, \text{kV}$
2. Heavy ions in NICA (Contnd)  3.2. Collider (Contnd)

**Collider luminosity vs Ion Energy**

Two outmost cases at $\Delta Q_{\text{Lasslett}} = \text{Const}$:

1) $L(E) = \text{Const}$ \implies $N_{\text{ion}}(E) \propto \frac{1}{\beta^2 \gamma^3}$, $\varepsilon_{\text{norm}} \propto \frac{1}{\beta^3 \gamma^5}$;

2) $N_{\text{ion}}(E) = \text{Const}$ \implies $\varepsilon_{\text{norm}} \propto \frac{1}{\beta \gamma^2}$, $L(E) \propto \beta^2 \gamma^3$.

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2. Heavy ions in NICA (Contnd)

2.2. Collider (Contnd)

IBS Heating and cooling - luminosity evolution at electron cooling

**BETACOOL** simulation

<table>
<thead>
<tr>
<th>B [kG]</th>
<th>Luminosity ([1\text{E}27 \text{ cm}^{-2} \cdot \text{s}^{-1}])</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

**Conclusion:** Electron magnetization is much more preferable

**Parameters**

- Ion beam: \(^{197}\text{Au}^{79+}\) at 3.5 GeV/u, \(\varepsilon_{\text{initial}} = 0.5 \pi \cdot \text{mm} \cdot \text{mrad}, (\Delta p/p) = 1 \cdot 10^{-3}\)
- Electron beam: \(I_e = 0.5 \, \text{A}, r_e = 2 \, \text{mm}, T_{e\|} = 5 \, \text{meV}; \eta = 0.024 (6 \, \text{m/250 m})\)

\(T_{e\perp} = 10 \, \text{eV} \Rightarrow \text{to reduce recombination!}\)
2. Heavy ions in NICA (Contnd)

2.2. Collider: electron cloud effect

Electron cloud formation criteria

The necessary condition: \( \left( N_{\text{bunch}} \right)_{\text{necessary}} \geq \beta^2 \cdot \frac{b^2}{Z r_e l_{\text{space}}} \),

The sufficient condition (“multipactor effect”):

\( \left( N_{\text{bunch}} \right)_{\text{sufficient}} \geq \frac{\beta b}{Z r_e} \sqrt{\frac{\epsilon_{\text{crit}}}{2m_e c^2}} \).

Here \( \beta c \) is ion velocity, \( Z \) - ion charge number, \( b \) - vacuum chamber radius, \( r_e \) - electron classic radius, \( l_{\text{space}} \) - distance between bunches, \( m_e \) - electron mass, \( c \) - the speed of light, \( \epsilon_{\text{crit}} \sim 1 \text{ keV} \) - electron energy sufficient for secondary electron generation.

For NICA bunch parameters \((10^9 \; ^{197}\text{Au}^{79+} \; \text{ions/bunch})\)

\( \left( N_{\text{bunch}} \right)_{\text{necessary}} \sim 7 \cdot 10^8, \quad \left( N_{\text{bunch}} \right)_{\text{sufficient}} \sim 6 \cdot 10^9. \)
3. Heavy ions in NICA (Contnd)  What is “old” and what is new?

3.2. Collider: the problems to be solved

- Collider SC dipoles with max B up to 4 T,
- “Flexible” lattice (transition energy change with energy),
- RF parameters (related problem),
- Single bunch stability,
- Vacuum chamber impedance and multibunch stability,
- Electron clouds (vacuum chamber coating?),
- Stochastic cooling of bunched ion beam,
- Electron cooling at electron energy up to 2.5 MeV.
3. Polarized particle beams in NICA

Longitudinal polarization formation

MPD

Spin rotator:
“Full Siberian snake”

Upper ring

“Siberian snake”: Protons, $1 \leq E \leq 12$ GeV $\Rightarrow (BL)_{\text{solenoid}} \leq 50$ T·m

Deuterons, $1 \leq E \leq 5$ GeV/u $\Rightarrow (BL)_{\text{solenoid}} \leq 140$ T·m
3. Polarized particle beams in NICA (Contnd)

Longitudinal polarization formation (Contnd)

MPD

“Full Siberian snake”

SPD

Lower ring
3. Polarized particle beams in NICA (Contnd)

Longitudinally polarized particles $\Rightarrow$ injection

\[ \alpha_\perp = \frac{(BL)_{dipole}}{(B\rho)_{ion}} \cdot (1 + \gamma a) \]

Longitudinally polarized particles $\Rightarrow$ injection

Protons, \( 1 \leq E \leq 12 \text{ GeV} \Rightarrow (BL)_{dipole} \leq 3 \text{ T} \cdot \text{m} \)

Deuterons, \( 1 \leq E \leq 5 \text{ GeV/u} \Rightarrow (BL)_{dipole} \leq 5.8 \text{ T} \cdot \text{m} \)
3. Polarized particle beams in NICA (Contnd)

Transverse polarization formation

Lower ring

MPD

Dipole “450”

B (45°)

Dipole “450”

B (45°)

B

SPD

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### Parameters of polarized proton beams in collider

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Energy, GeV</th>
<th>5</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proton number per bunch</td>
<td></td>
<td>6E10</td>
<td>1.5E10</td>
</tr>
<tr>
<td>Rms relative momentum spread</td>
<td></td>
<td>10E-3</td>
<td>10E-3</td>
</tr>
<tr>
<td>Rms bunch length, m</td>
<td></td>
<td>1.7</td>
<td>0.8</td>
</tr>
<tr>
<td>Rms (unnormalized) emittance, $\pi \cdot \text{mm} \cdot \text{mrad}$</td>
<td></td>
<td>0.24</td>
<td>0.027</td>
</tr>
<tr>
<td>Beta-function in the IP, m</td>
<td></td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Lasslet tune shift</td>
<td></td>
<td>0.0074</td>
<td>0.0033</td>
</tr>
<tr>
<td>Beam-beam parameter</td>
<td></td>
<td>0.005</td>
<td>0.005</td>
</tr>
<tr>
<td>Number of bunches</td>
<td></td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Luminosity, cm$^{-2} \cdot$s$^{-1}$</td>
<td></td>
<td>1.1E30</td>
<td>1.1E30</td>
</tr>
</tbody>
</table>
3. Polarized particle beams in NICA (Contnd)

Polarized particle acceleration in Nuclotron:

Spin resonances

<table>
<thead>
<tr>
<th>Type of resonance</th>
<th>Resonance condition</th>
<th>Number of resonances at acceleration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Intrinsic res.</td>
<td>$Q_s = kp \pm Q_z$</td>
<td>$p^{\uparrow}$ 6 \hspace{1cm} $d^{\uparrow}$ 0 (5.6 GeV/u)</td>
</tr>
<tr>
<td>2. Integer res.</td>
<td>$Q_s = k$</td>
<td>25</td>
</tr>
<tr>
<td>3. Nonsuperperiodic</td>
<td>$Q_s = m \pm Q_z , m \neq kp$</td>
<td>44</td>
</tr>
<tr>
<td>4. Coupling res.</td>
<td>$Q_s = m \pm Q_x$</td>
<td>49</td>
</tr>
</tbody>
</table>

$Q$ – betatron and spin precession tunes, $k, m$ – integers, $p$ – number of superperiods (8 for Nuclotron)

Power of the Spin resonances: $P_{1,2} \sim 10^3 \cdot P_{3,4}$
4. Polarized particle beams in NICA (Contnd)

Polarized proton acceleration in Nuclotron:

Crossing of spin resonances

Fast spin rotator

Protons, 12 GeV, $\Delta Q \sim 0.01$, $\Delta t = 50 \mu s$

$\Delta Q_s = \Delta \phi_x \cdot \Delta \phi_y / 2\pi$ per 1 turn

$\Delta \phi_x \sim 0.2$, $B_x L_x = 0.18 \text{T} \cdot \text{m}$, $\Delta \phi_y \sim 0.2$, $B_s \cdot L_s = 4.7 \text{T} \cdot \text{m}$
4. NICA project status and plans

January 2008

NICA CDR

January 2009

NICA CDR (Short version)
4. NICA project status and plans (Contnd)

Since publication of the 1-st version of the NICA CDR
The Concept was developed, the volumes I and II of the
TDR have been completed:
Volume I – Part 1, General description
    Part 2, Injector complex
Volume II – Part 3, Booster-Synchrotron
4. NICA project status and plans (Contnd)

August 2009
NICA TDR (volumes I & II)

Ускорительно-накопительный комплекс NICA
(Nuclotron-based Ion Collider FACility)
Технический проект
Том I

Дубна, 2009

Ускорительно-накопительный комплекс NICA
(Nuclotron-based Ion Collider FACility)
Технический проект
Том II

Дубна, 2009

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4. NICA project status and plans (Contnd)

Nuclotron-based Ion Collider fAcility (NICA)
Technical Design Report
Project leaders: A.Sisakian, A.Sorin

Approved by
Director of JINR
academician A.N.Sisakian

"____" 2009 г.

Nuclotron-based Ion Collider fAcility (NICA) Technical Design Report
Project leaders: A.Sisakian, A.Sorin

TDR has been developed by the NICA collaboration:

JINR


IHEP, Protvino
O.Belyaev, Yu.Budanov, S.Ivanov, A.Maltsev, I.Zvonarev,

INR RAS, Troitsk
V.Matveev, A.Belov, L.Kravchuk


Chief engineer of the Project  V.Kalagin,  
Chief designer of the Project  N.Topilin

Editors: I.Meshkov, A.Sidorin
## 4. NICA project status and plans

<table>
<thead>
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<th></th>
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</thead>
<tbody>
<tr>
<td>KRION</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LINAC + trans. channel</td>
<td></td>
<td></td>
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<tr>
<td>Booster: magnetic system</td>
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<tr>
<td>Nuclotron-M</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td>Nuclotron-NICA</td>
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<tr>
<td>Transfer channel to Collider</td>
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<tr>
<td>Collider</td>
<td></td>
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</table>
4. NICA project status and plans

4.1. Injector

HILAC – Heavy ion linac RFQ + Drift Tube Linac (DTL), under design and construction (O.Belyaev & the Team, IHEP, Protvino).

KRION - Cryogenic ion source of “electron-string” type developed by E.Donets group at JINR. It is aimed to generation of heavy multicharged ions (e.g. $^{197}$Au$^{32+}$).

RFQ Electrodes

2H cavities of “Ural” RFQ (prototype)

Sector H-cavity of “Ural” RFQ DTL (prototype)

To be commissioned in 2013.
4. NICA project status and plans

4.2. Booster

“Nuclotron-type” SC magnets for Booster

\[ B_\rho = 25 \, \text{T} \cdot \text{m}, \quad B_{\text{max}} = 1.8 \, \text{T} \]

1) 3 single-turn injections
2) Storage and electron cooling of \( 8 \times 10^9 \, ^{197}\text{Au}^{32+} \)
3) Acceleration up to 600 MeV/u
4) Extraction & stripping

A. Butenko
V. Mikhailov
G. Khodjibagiyan
N. Topilin

I. Meshkov, G. Trubnikov
Status of NICA Project
Seminar at BNL
November 5, 2009
The technical design of the Booster is in progress.
The Booster is to be commissioned in 2013.
4. NICA project status and plans

4.2. Booster (Contnd)

SC magnet technology

SC hollow cable
RF system (designed by Budker INP)

<table>
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<tr>
<th>Parameter</th>
<th>Value</th>
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<tr>
<td>Frequency range, MHz</td>
<td>0.6 ÷ 2.4</td>
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<td>Maximum voltage amplitude, kV</td>
<td>10</td>
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<tr>
<td>Number of cavities</td>
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<tr>
<td>Cavity length, m</td>
<td>1.4</td>
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<tr>
<td>RF tube type</td>
<td>EIMAC 4XC15.000A</td>
</tr>
</tbody>
</table>
4. NICA project status and plans

4.2. Booster (Contnd)

E.Ahmanova, I.Meshkov, A.Smirnov, N.Topilin, Yu.Tumanova, S.Yakovenko

Electron cooling system of the Booster

electron gun

collector

“warm” solenoids

cryogenic shield

superconducting solenoids
Electron cooling system of the Booster (Contnd)
4. NICA project status and plans

4.3. Nuclotron-NICA

G. Trubnikov & the Team

To be designed, constructed and commissioned:

1. Injection system (new HILAC)
2. RF system – new version with bunch compression
3. Dedicated diagnostics
4. Single turn extraction with fine synchronization
5. Polarized protons acceleration in Nuclotron

To be commissioned in 2013.
4. NICA project status and plans

4.4. Collider

Double ring collider: \((B\rho)_{\text{max}} = 45 \text{ T}\cdot\text{m}, B_{\text{max}} = 4 \text{ T}\)

“Twin magnets” for NICA collider rings

“A.Kovalenko
G.Khodjibagiyan
I.Meshkov, G.Trubnikov
Status of NICA Project
Seminar at BNL
November 5, 2009

To be commissioned in 2014.
4. NICA project status and plans

4.4. Collider (Contnd)

Double ring collider; \((B\rho)_{\text{max}} = 45 \, \text{T} \cdot \text{m}, \ B_{\text{max}} = 4 \, \text{T}\)

“Twin magnets” for NICA collider rings

G. Khodjibagiyan et al.
4. NICA project status and plans

4.4. Collider

Electron cooling system of the Collider

Max electron energy, MeV  2.5
Max electron current, A    0.5
Solenoid magnetic field, T  0.3

“Magnetized” electron beam
Solenoid type: “warm” at acceleration columns
superconducting at transportation and cooling sections

HV generator: Dynamitron type

To be commissioned in 2014.

Under development in collaboration with
- All-Russian Institute for Electrotechnique (Moscow)
- FZ Juelich
- Budker INP
GSI/JINR/BNL 2005 - 2009
Round Table Discussions I, II, III, IV
http://theor.jinr.ru/meetings/2008/roundtable/

✓ Booster RF system
✓ Booster electron cooling
✓ Collider RF system
✓ Collider SC magnets (expertise)
✓ HV electron cooler for collider
✓ Electronics (?)

All-Russian Institute for Electrotechnique
HV Electron cooler

GSI/FAIR
SC dipoles for Booster/SIS-100
SC dipoles for Collider

Corporation “Powder Metallurgy” (Minsk, Belorussia):
Technology of TiN coating of vacuum chamber walls for reduction of secondary emission

Collaboration

IHEP (Protvino)
Injector Linac

FZ Jülich (IKP)
HV Electron cooler
Stoch. cooling

BNL (RHIC)
Electron & Stoch. Cooling

ITEP: Beam dynamics in the collider

I.Meshkov, G.Trubnikov    Status of NICA Project       Seminar at  BNL       November 5, 2009
Thank you for your attention!
5. NICA project status and plans

"The ambush regiment" 5.5. "Collider 2T"

V. Kalagin
I. Meshkov
V. Mikhailov
G. Trubnikov

Collider:
C_Ring 380 м
Dipoles 2 Тл

Luminosity?
5. NICA project status and plans

5.5. “Collider 2Т” (Contnd)

Dipoles 2 Тл

Victor Yarba, Alexander Zlobin:
“Common coils” technology
Fermilab, October 30, 2009