NICA accelerator complex

NICA: Nuclotron based Ion Collider fAcility

General information

NICA is an international project
realizing by international intergovernmental organization –
the Joint Institute for Nuclear Research
and brings the efforts of 18 member states and 6 associated countries.

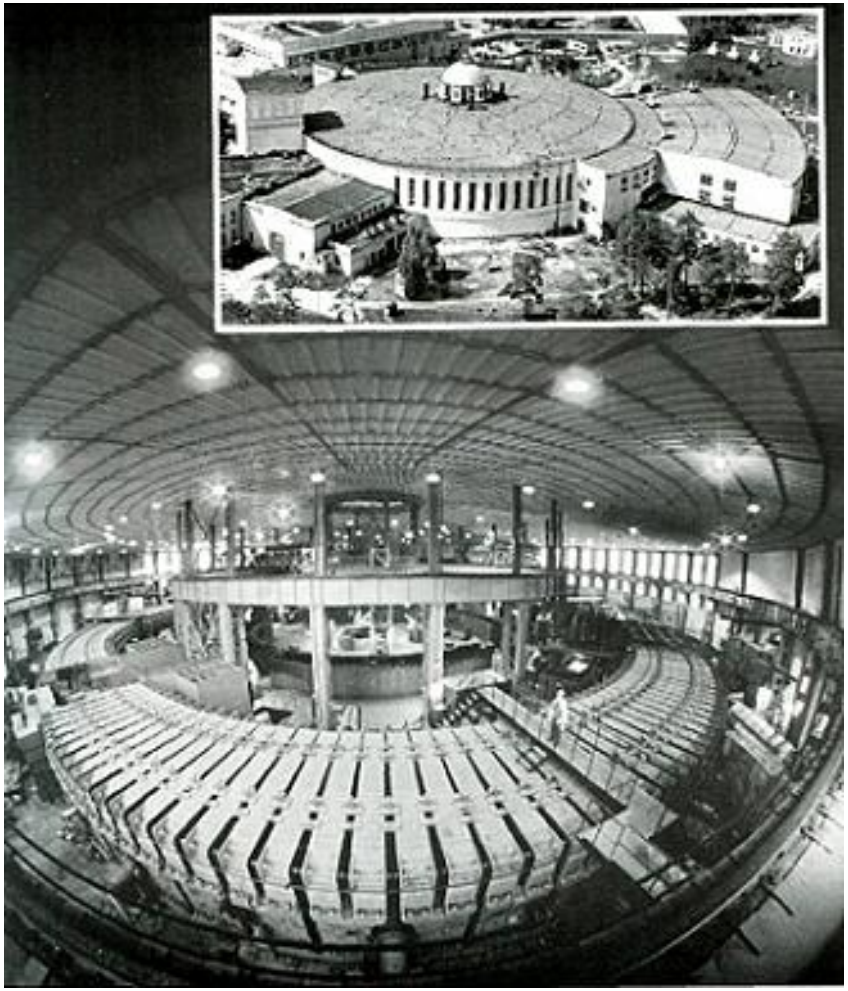
Project NICA started as a part of the JINR Roadmap for 2009-2016
was described in the JINR 7-years Program.
It was approved by Scientific Council of JINR and
the Committee of Plenipotentiaries of JINR in 2009.
NICA is a flagship project of JINR presently.

In 2016 between RF and JINR was signed a contract
presuming start of operation of basic configuration of the NICA complex in 2020.

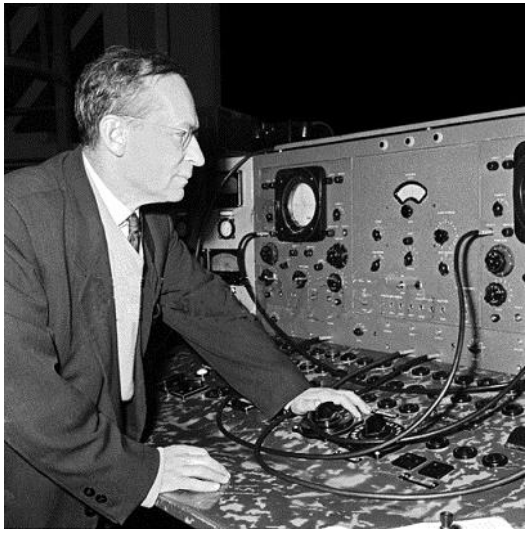
In 2017 the project was included into ESFRI road map.

Project web-site: http://nica.jinr.ru/

Relativistic nuclear physics



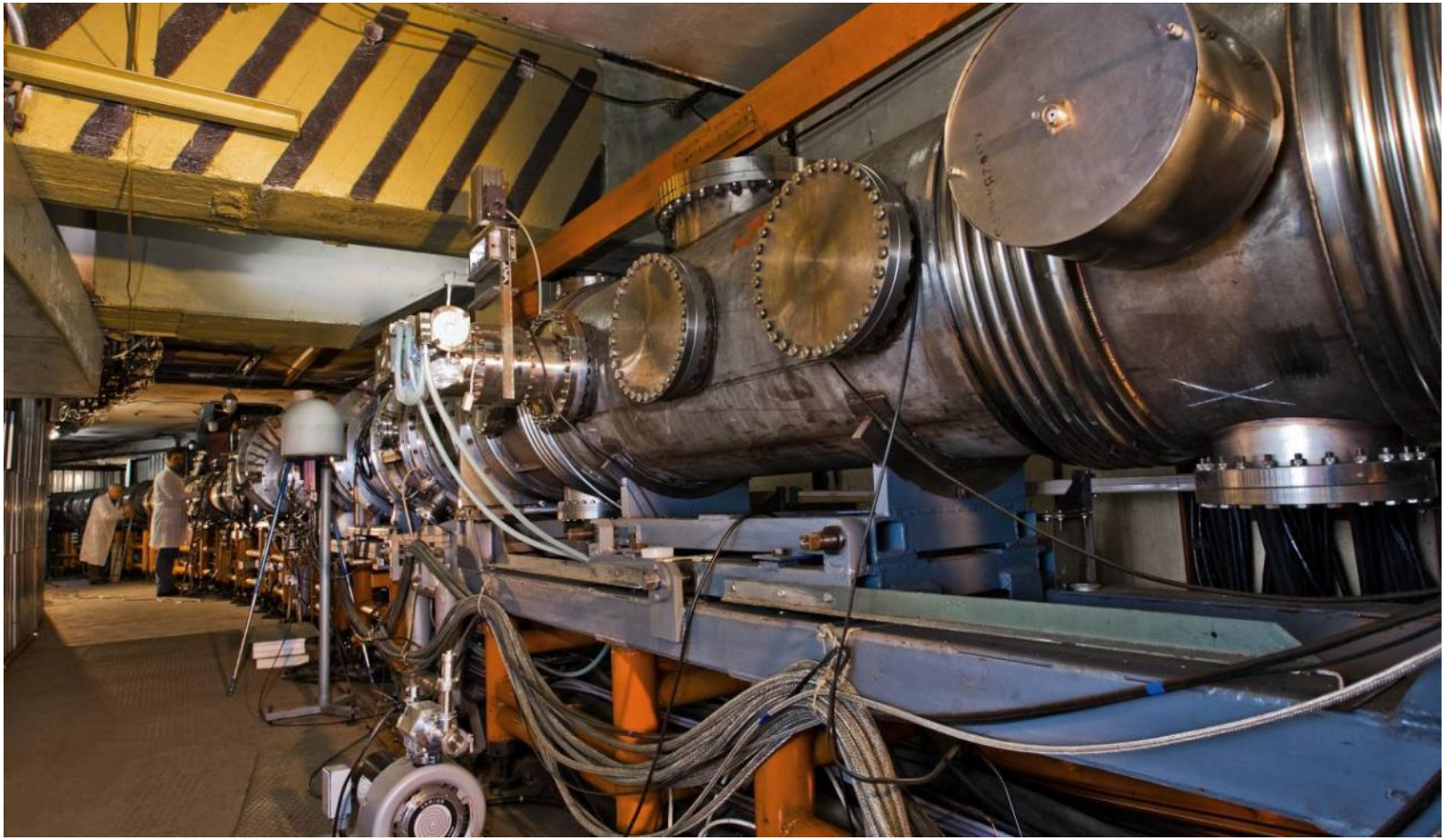
End of 60-th – acceleration of ions
70-th – observation of nuclear cumulative effect



V.I. Veksler

A.M.Baldin

First Superconducting heavy ion accelerator



Nuclotron – Superconducting Synchrotron operation since 1993

The primary purpose of the NICA construction

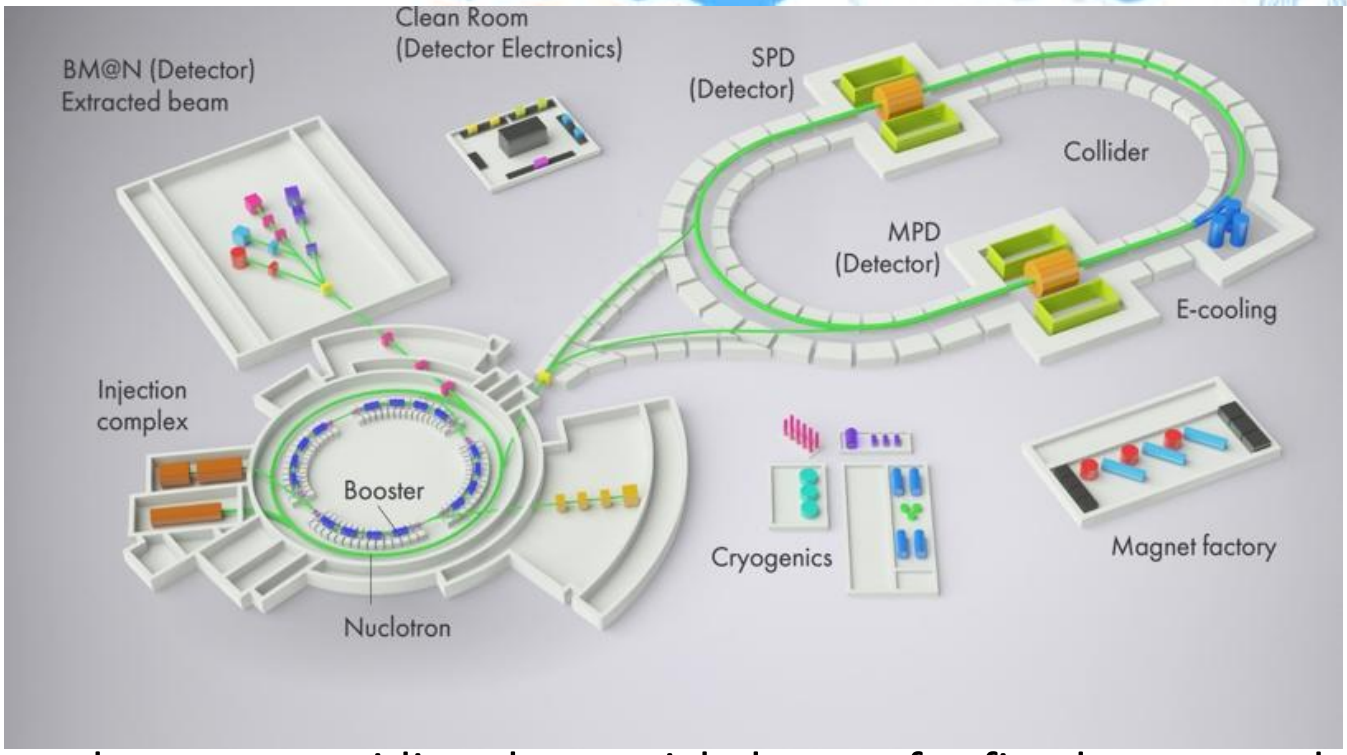
The project comprises experimental studies of **fundamental** character in the fields of the following directions:

- Relativistic nuclear physics;
- Spin physics in high and middle energy range of interacting particles;
- Radiobiology.

Applied researches based on particle beams generated at NICA are dedicated to development of novel technologies in material science, environmental problems resolution, energy generation, particle beam therapy and others.

Education program is one of the first priority activities at JINR, as formulated in JINR Roadmap.
The proposed NICA facility offers various possibilities for teaching and qualification procedures including practice at experimental set ups, preparation of diploma works, PhD, and doctoral theses.

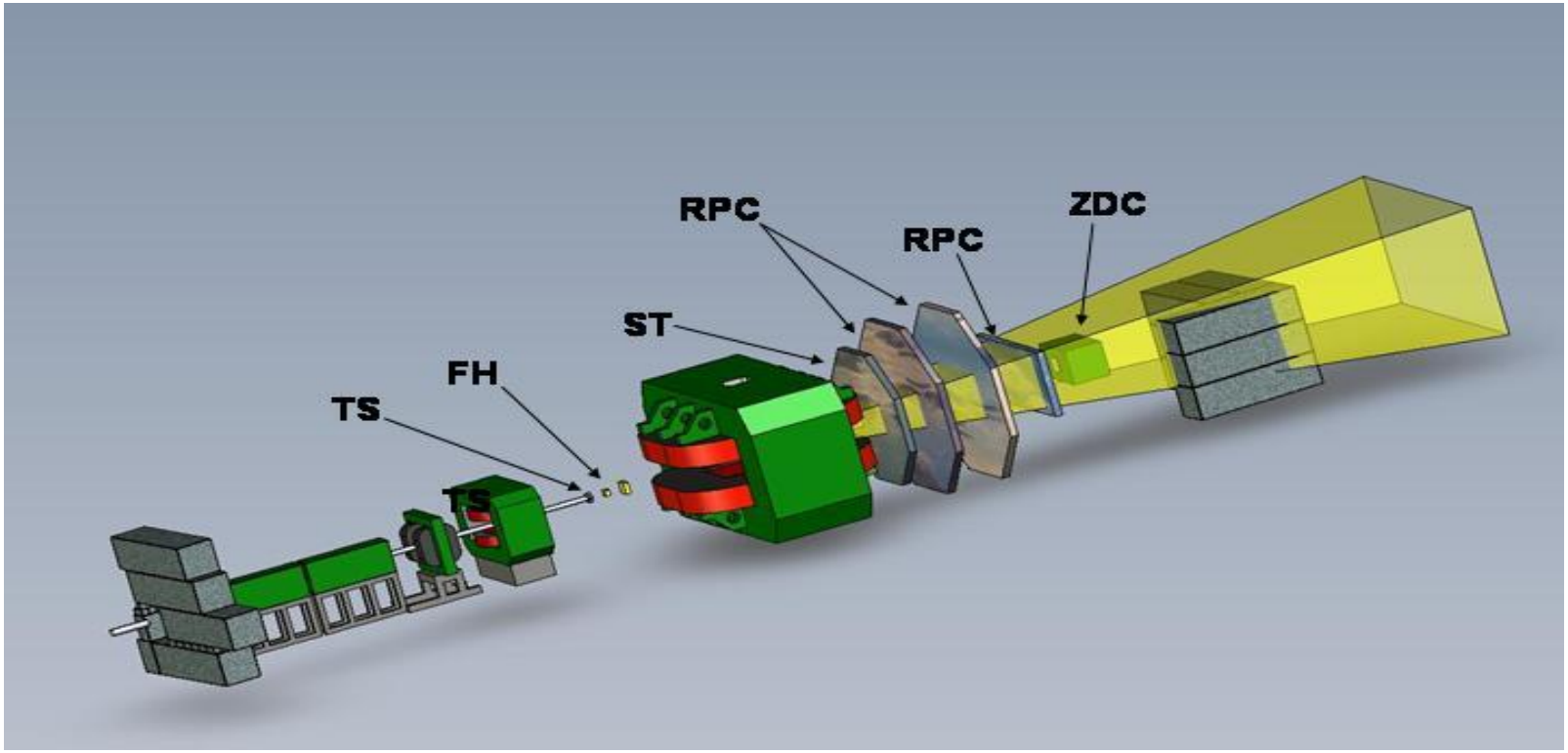
The NICA complex includes:



- Set of accelerators providing the particle beams for fixed target and collider experiments,
- Experimental facilities,
- Line for assembling and cryogenic testing of SC-magnets,
- Workshops for construction of the detector elements,
- NICA innovation center,
- Required infrastructure.

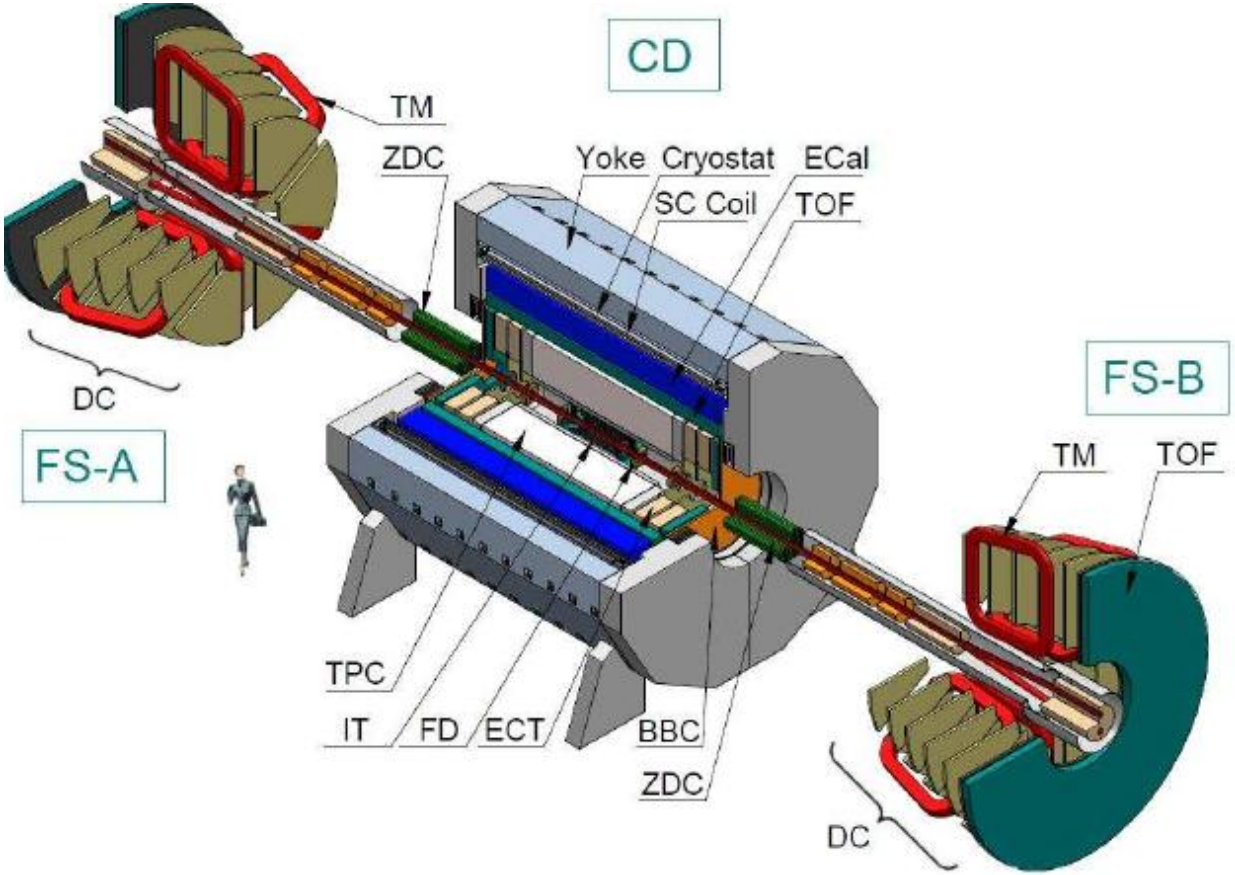
Main experimental facilities

Baryonic Matter at Nuclotron (BM@N) –
fixed target experiment at the Nuclotron extracted beams
which main goals are investigations of strange / multi-strange hyperon,
hypernuclei production and short range correlations.



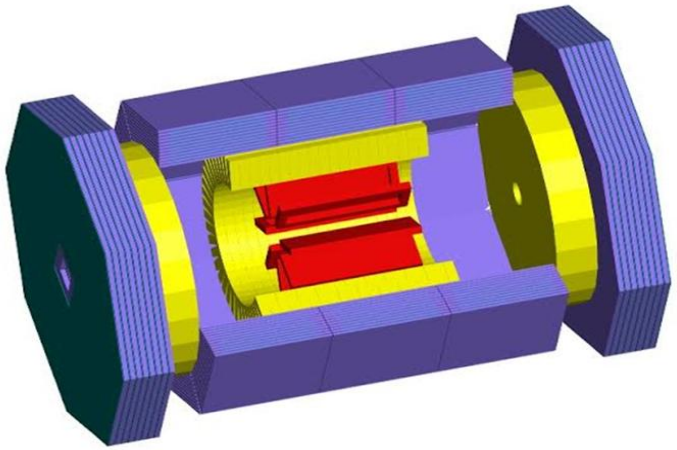
Main experimental facilities

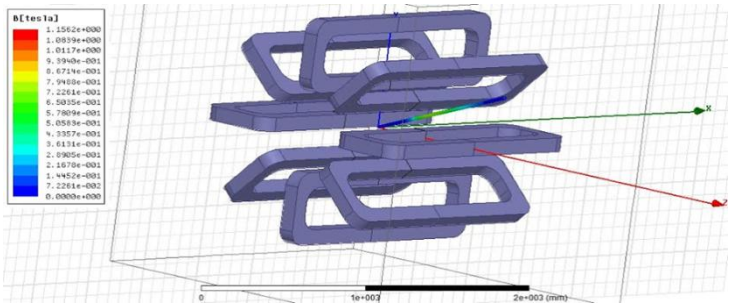
Multi Purpose Detector (MPD)
aiming to study of hot and dense strongly interacting matter in heavy ion (up to Au) collisions at the centre-of-mass energy range of max baryonic density (up to 11 GeV).

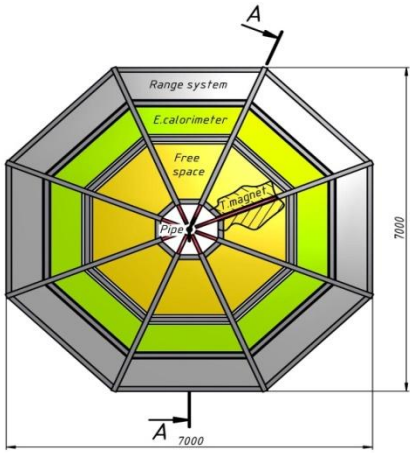


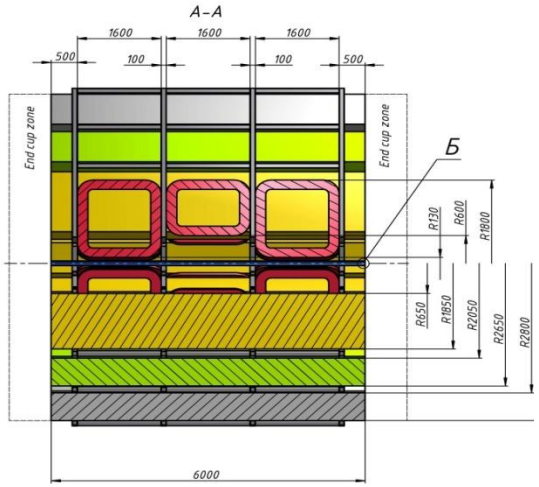
Main experimental facilities

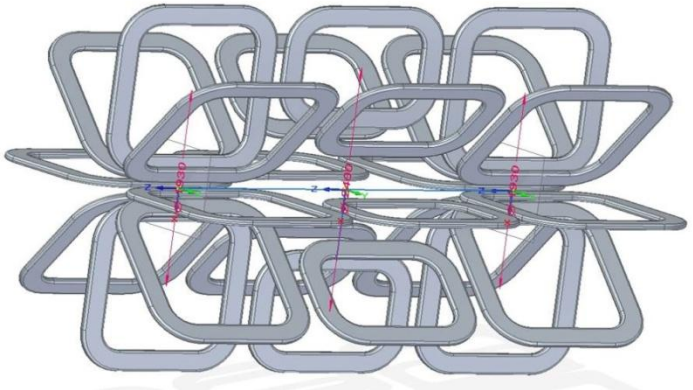
Spin Physics Detector (SPD) aiming to study of spin physics with colliding beams of polarized deuterons and protons at the energies up to 27 GeV (for protons).







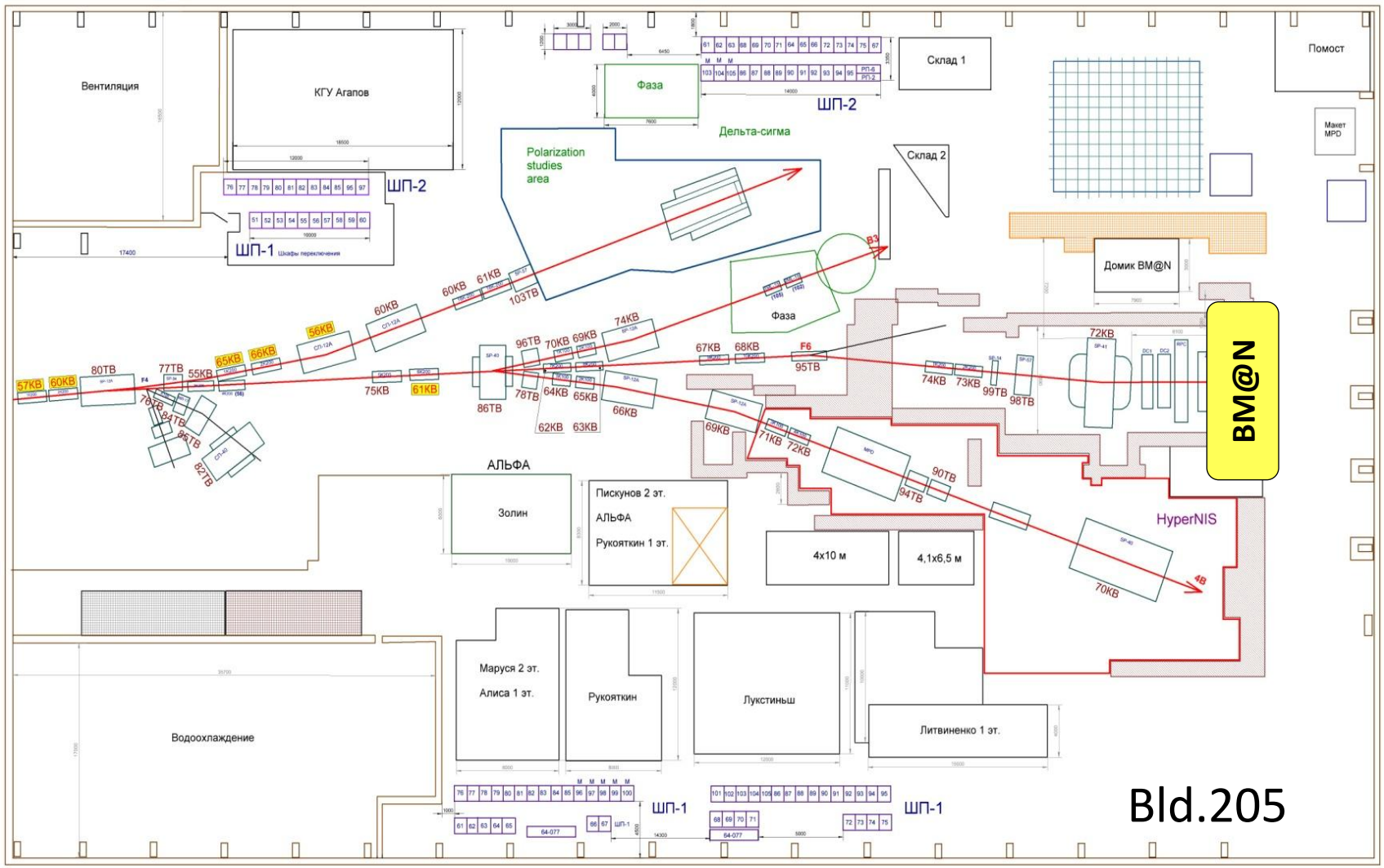




Main experimental facilities

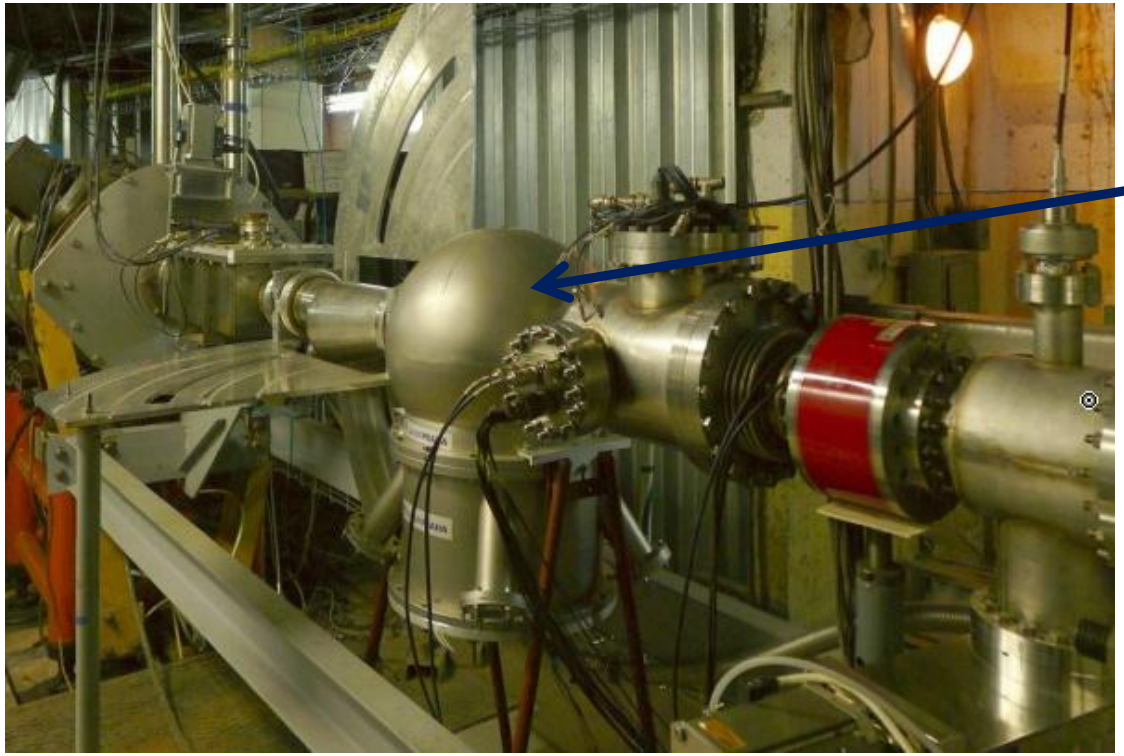
Area for radiobiology and applied research

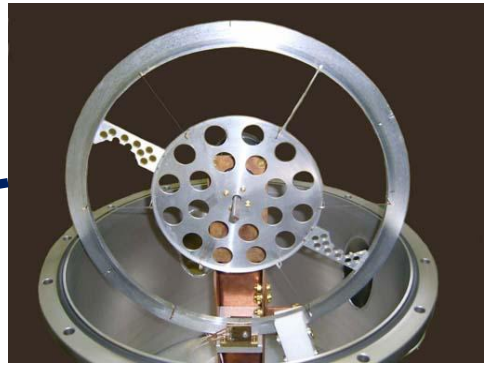
is under development in the existing experimental building.



Main experimental facilities

The Nuclotron internal target station equipped with six different targets: wire, strip and film with material from hydrogen to tungsten dedicated for particle physics, spin physics, relativistic atomic physics experiments.





New buildings of the NICA complex

NICA innovation center

Collider building

New compressor hall building

New buildings of the NICA complex

Collider building

http://nucloweb.jinr.ru/nucloserv/205corp.htm

New buildings of the NICA complex

NICA innovation center

- cluster of JINR computer center dedicated to collect and process the data from NICA detectors,
- 500 offices for scientists,
- laboratory rooms for preparation of experimental equipment and fast analysis of results,
- conference hall

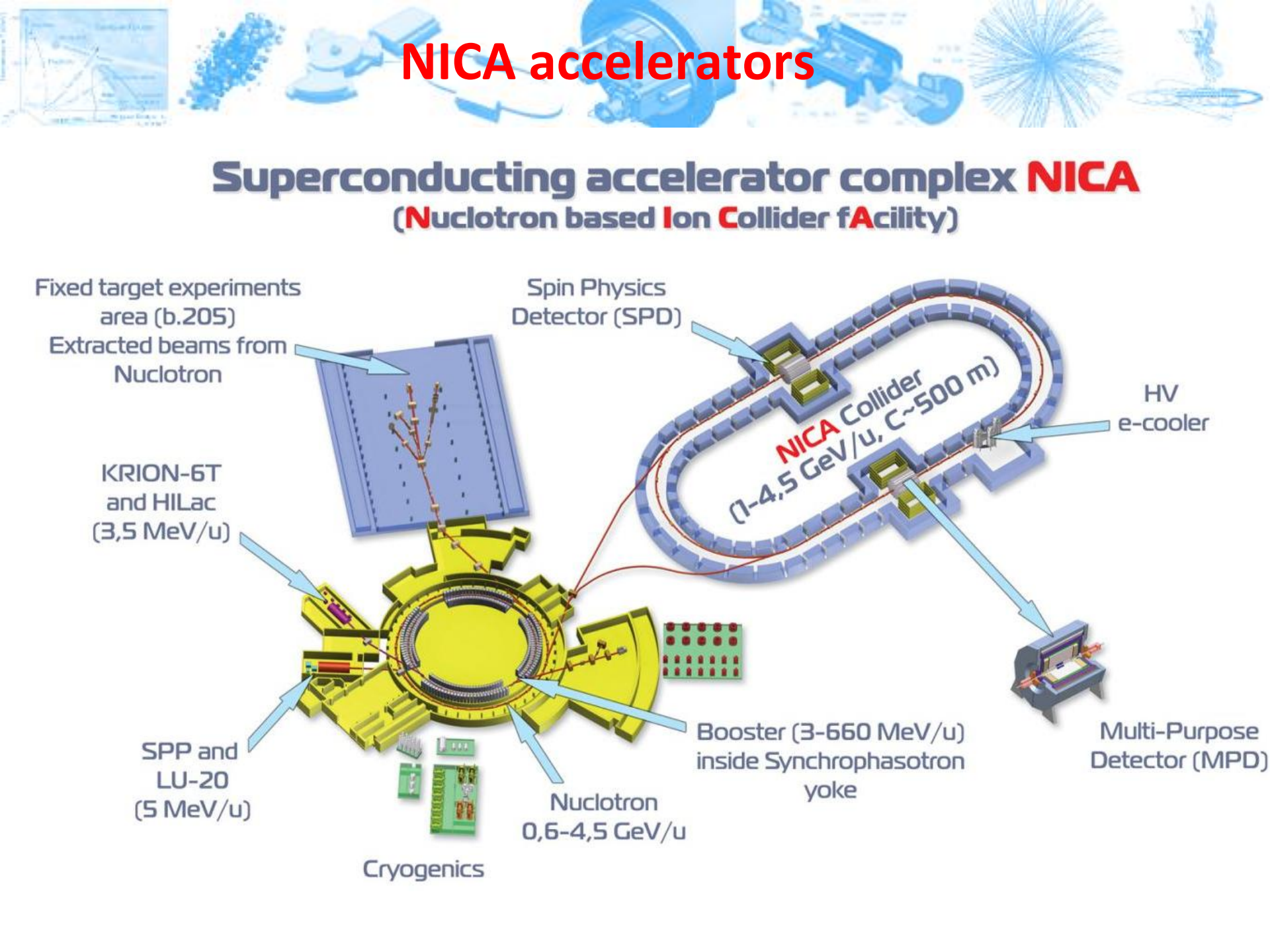
Line for assembling and cryogenic testing of SC-magnets

Main production areas:

- Incoming inspection zone
- SC cable production hall
- SC coils production hall
- Area for assembling the magnets
- Area for the magnetic measurements under the room temperature
- Leakage test area
- Area for mounting the SC-magnets inside cryostats
- Cryogenic tests bench

450 magnets for NICA and FAIR projects

NICA accelerators



NICA accelerators

Main accelerator of the NICA complex is **the Nuclotron** –
superconducting ion synchrotron at magnetic rigidity of about 42 T·m
equipped with two injection chains: for heavy and for light ions.

Injection chain for heavy ions consists of:
the ion source (KRION-6N), heavy ion linear accelerator (HILac),
superconducting booster synchrotron (Booster) and required beam transport lines.

Injection chain for light ions includes:
Laser ion source (LIS), Source of polarized ions (SPI), Duoplasmatron,
RFQ accelerator as a foreinjector, Drift tube linac of Alvarec type (LU-20)
and required beam transport lines.

The collider experiments will be provided at two storage rings
with two interaction points (IP).

NICA accelerators

Injection chain for heavy ions

Cryogenic heavy ion source KRION

of Electron String Ion Source (ESIS) type

provides up to $2.5 \cdot 10^9$ Au^{31+} particles per cycle

at repetition frequency up to 10 Hz

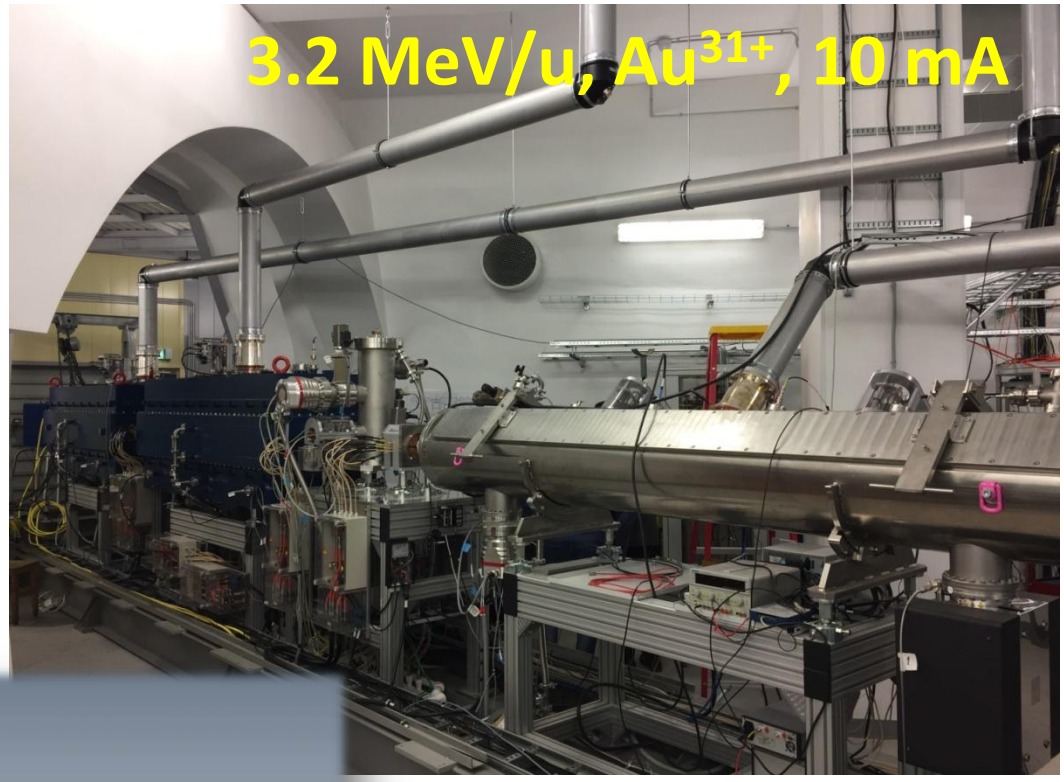
NICA accelerators

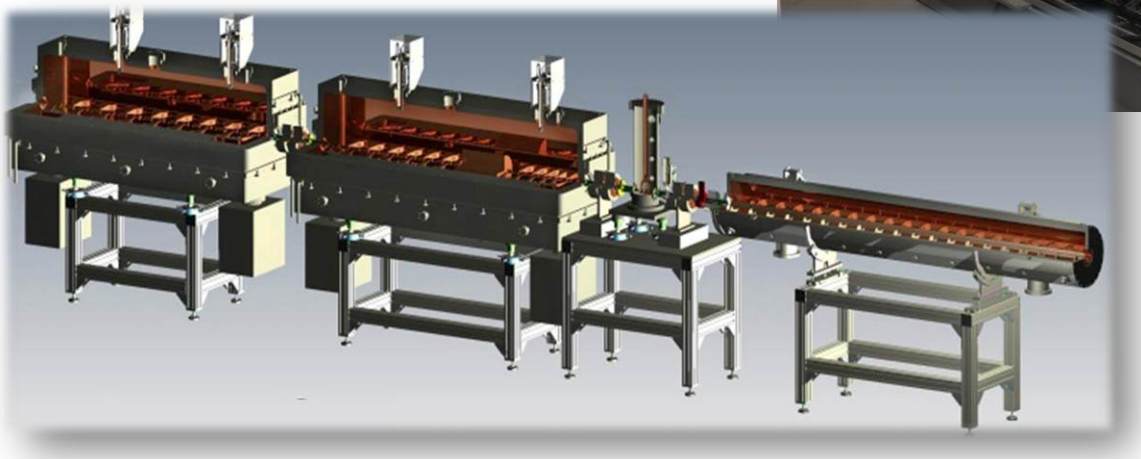
Injection chain for heavy ions

Heavy ion linear accelerator (HILac)

First in Russia
high current (10 mA) heavy ion Linac
(designed and constructed in Germany)

First Linac with transistor RF amplifier
(fabricated in Australia)



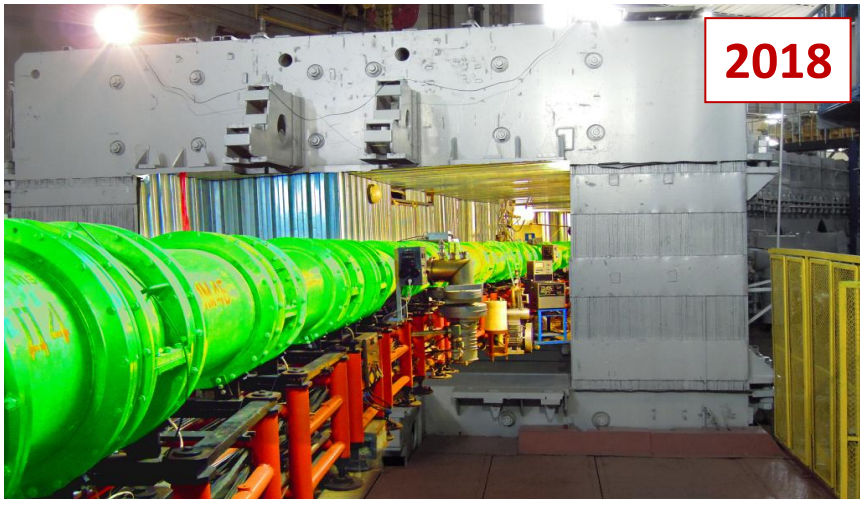


NICA accelerators

Injection chain for heavy ions

The Booster should accelerate ions up to 600 MeV/u (for ions with $Z/A = 1/3$).
The magnetic ring of 211 m long is placed inside the window of the Synchrophasotron yoke.

To provide the required beam quality the Booster is equipped with electron cooling system.

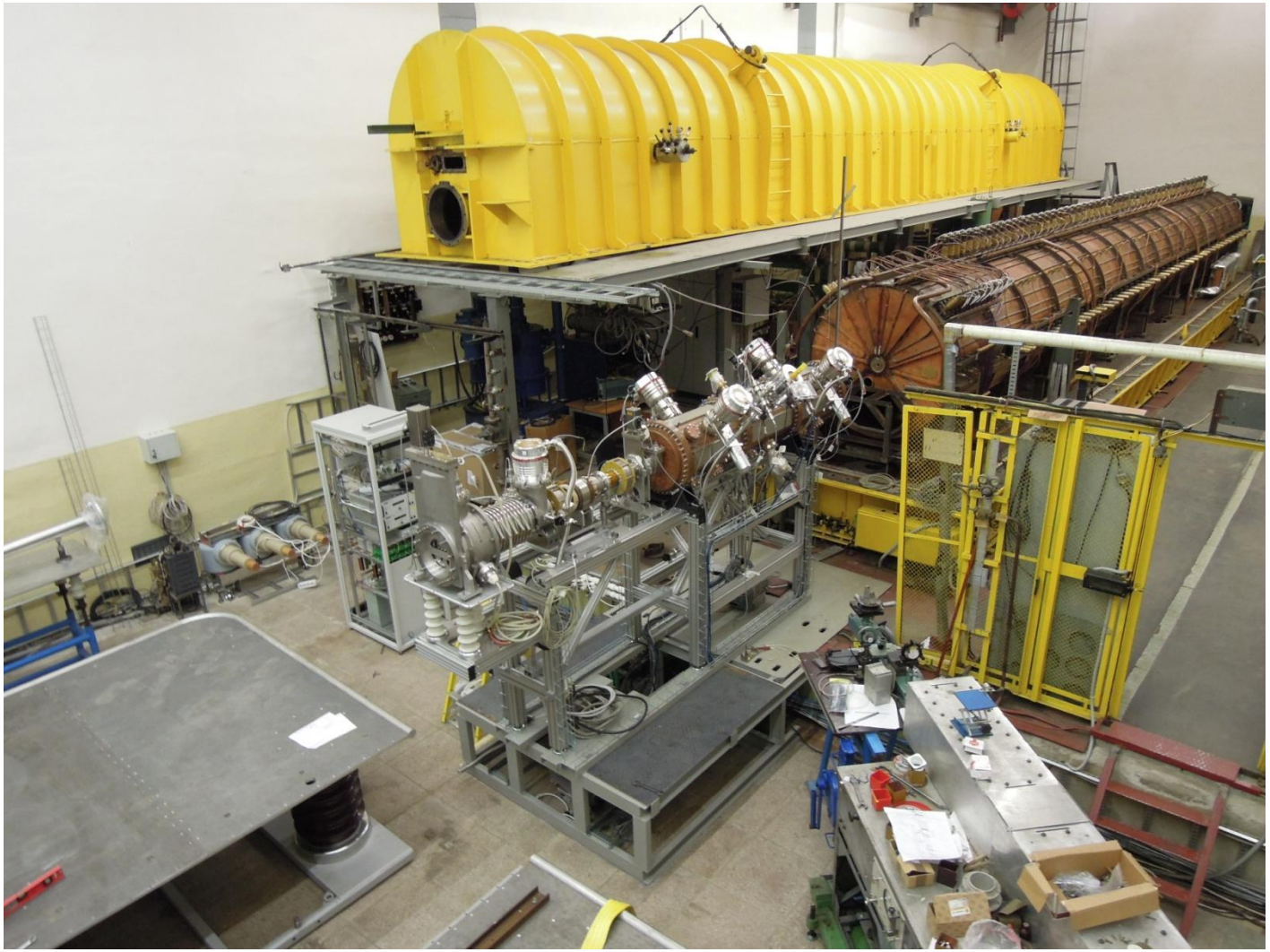


NICA accelerators

Injection chain for light ions

NICA accelerators

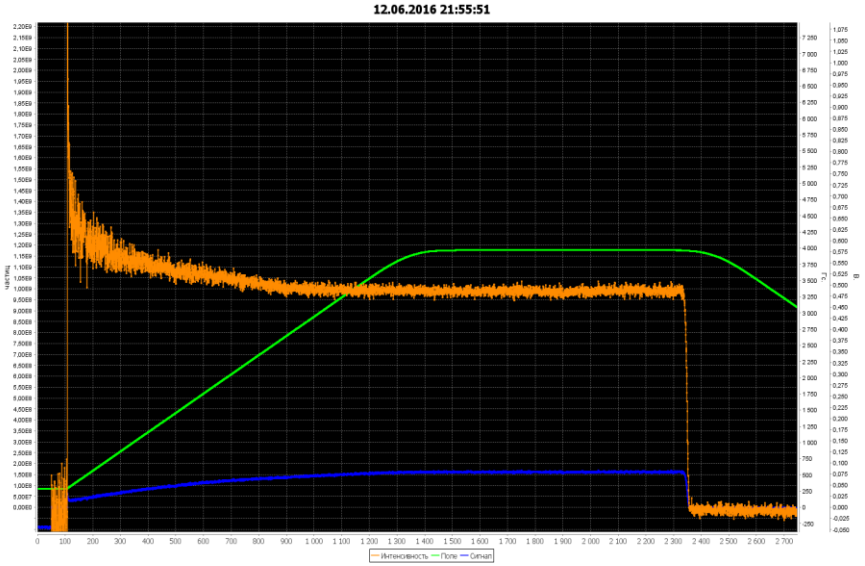
Injection chain for light ions



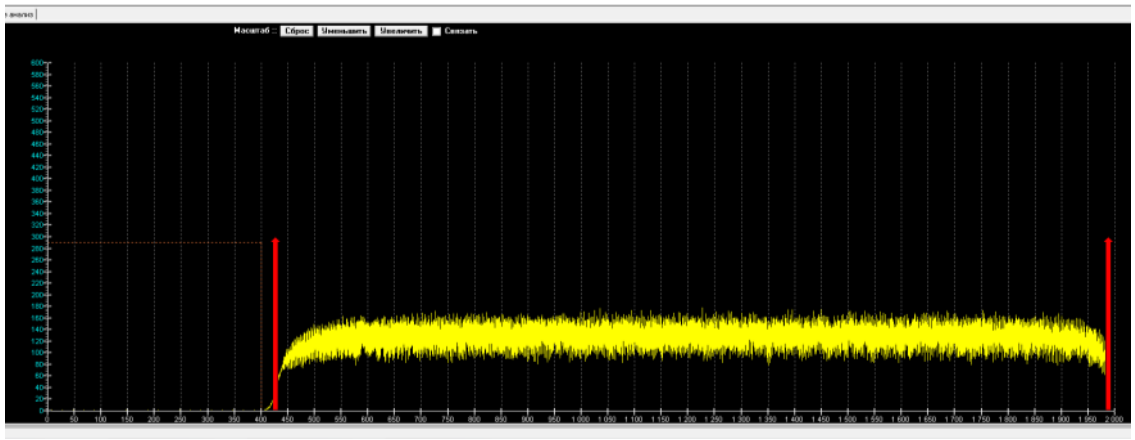
NICA accelerators

Nuclotron

Nuclotron provides now performance of experiments on accelerated proton and ion beams (up to Xe^{42+}, $A=124$) with energies up to 6 GeV/u (Z/A = 1/2) 4.5 GeV/u for Au



Deuteron energy 750 MeV/u, intensity 10^9



Slow extraction system: beam spill up to 20 s

NICA accelerators

Collider

The Collider ring 503.04 m long has a racetrack shape and is based on double-aperture (top-to-bottom) superconducting magnets at maximum dipole field 1.8 T;

The major parameters of the NICA Collider are the following:
- magnetic rigidity = 45 T·m;
-ion kinetic energy range from 1 GeV/u to 4.5 GeV/u for Au^{79+};
-energy of polarized deuterons is 6 GeV/u, protons – 12 GeV,

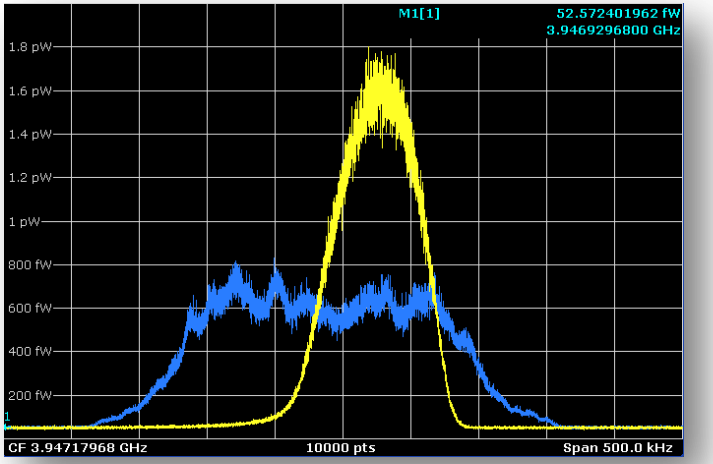
- vacuum in a beam chamber: 10^{-11} Torr;
- zero beam crossing angle at IP;
- 9 m space for detector allocations at IP's;

Average luminosity 10^{27} $cm^{-2}\cdot s^{-1}$ for gold ion collisions at $\sqrt{s_{NN}}$ = 9 GeV.
The luminosity in the polarized mode is up to 10^{32} $cm^{-2}\cdot s^{-1}$.

NICA accelerators

Collider

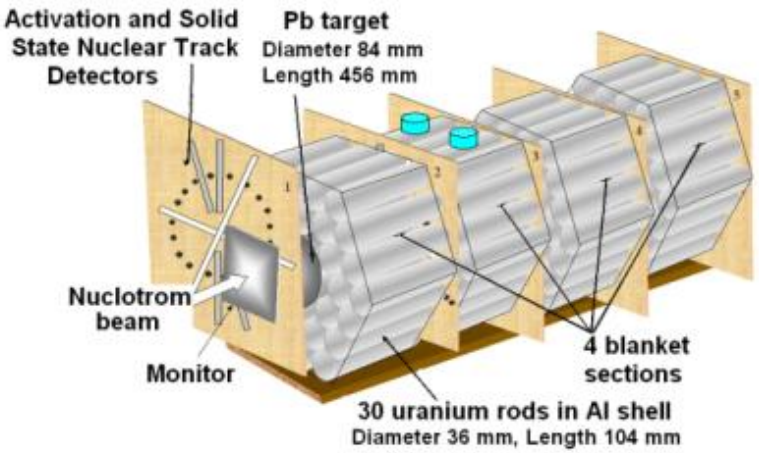
Stochastic cooling system



Successive test at the Nuclotron 2013

Innovations based on NICA technologies

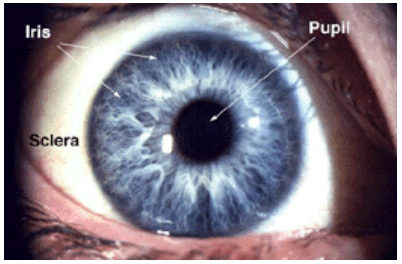
Transmutaion of nuclear fuel waste

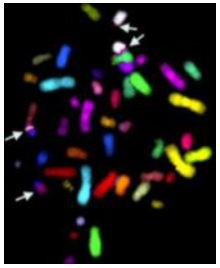


Testing of space craft elements and electronics

Design and Development of accelerator and detector technologies for medicine

Radiobiology and medicine





NICA: Education

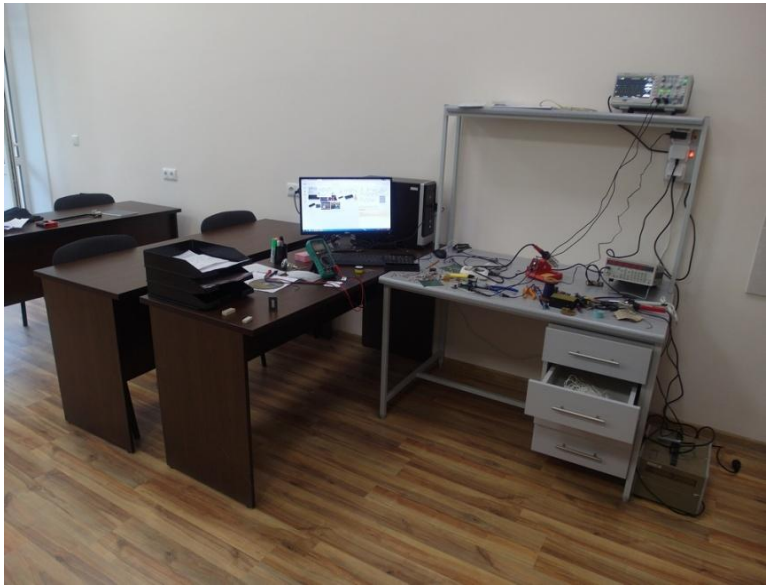
Realization of the NICA experimental program presumes construction and a few consequent upgrades of large accelerator complex during 15 – 20 years.

Within this period high level specialists will be educated in the following fields:

- **Industrial electronics**
- **Vacuum technique**
- **RF engineering**
- **Accelerator physics and technique**
- **Superconducting magnetic systems**
- **Cryogenics**
- **Automatic control systems**
- **Particle detectors**
- **Radiation safety**

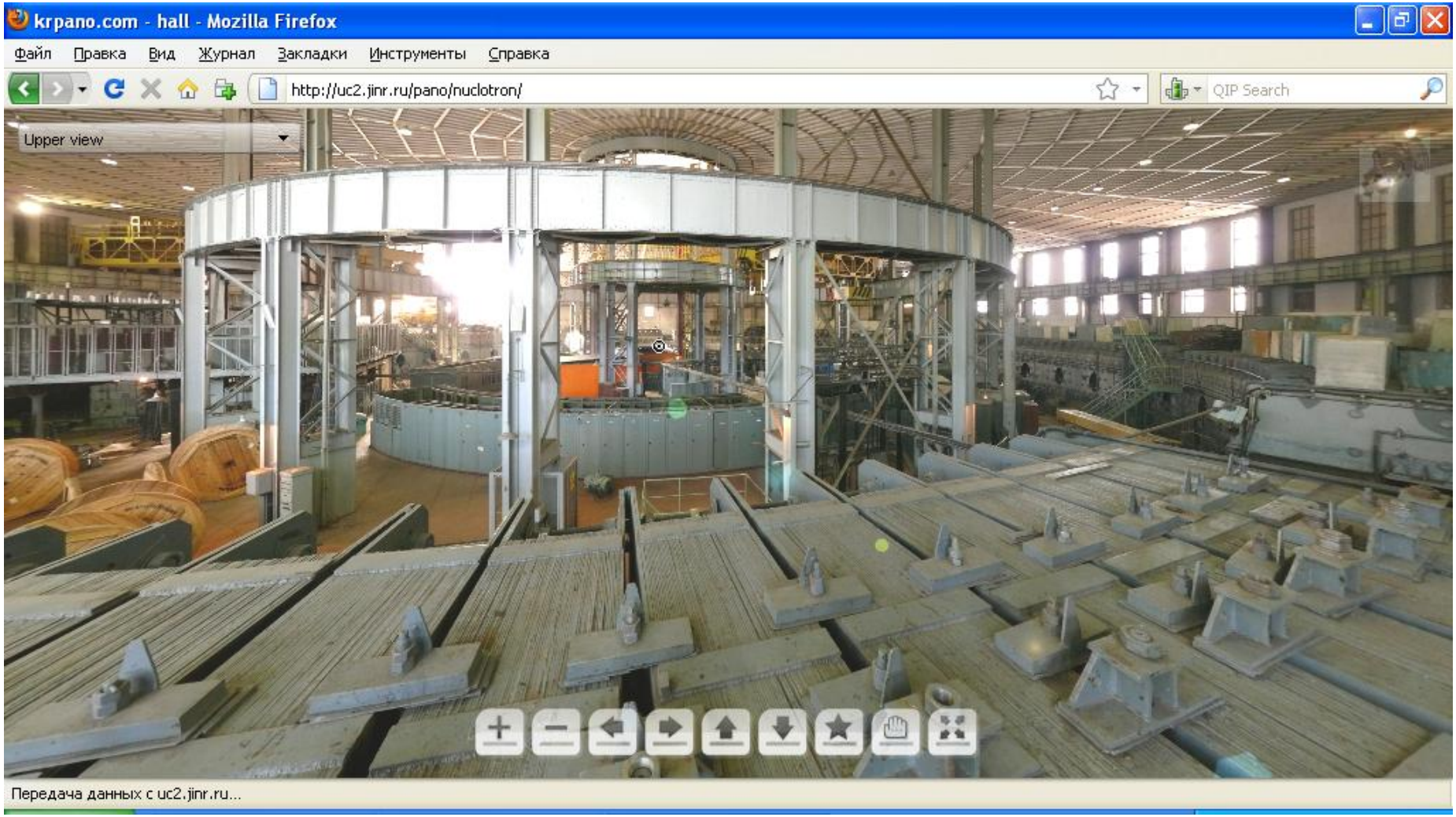
JINR University Center

Practice in:
-Vacuum technique
-RF engineering
-Industrial electronics
-Radiation safety
-Linear accelerators
-Free electron lasers



First international student team got the practice in July 2015

Virtual excursions



http://uc2.jinr.ru/pano/nuclotron/


Start of the collider operation 2020