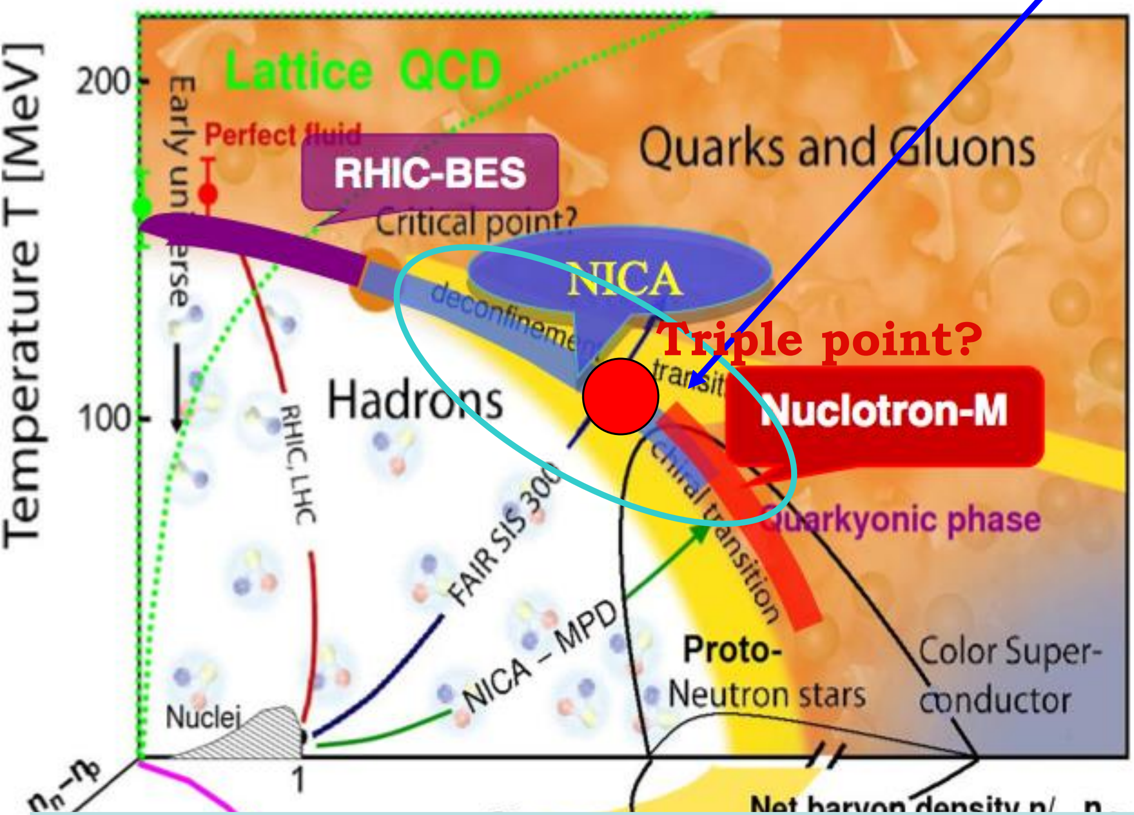
Present Status of NICA Project

Alexander Smirnov, **JINR, Dubna, Russia**

on behalf of NICA team

NICA Physics case. QCD phase diagram

Deconfinement matter (high ε,T,nB):
ε >1 GeV/fm3, T>150 MeV, nB>(3-5)n0



The most intriguing and little studied region of the QCD phase diagram:

- **Characterized by the highest net baryon density**
- **Allows to study in great detail properties of the phase transition region**
- **Has strong discovery potential in searching for the Critical End Point and manifestation of Chiral Symmetry Restoration**

Recently became very attractive for heavy-ion community: RHIC/BNL, SPS/CERN, FAIR/GSI, NICA/JINR

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

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

The goal of the project is

<u>construction at JINR of a new accelerator facility,</u> that provides

1a) Heavy ion colliding beams $^{197}Au^{79+}$ x $^{197}Au^{79+}$ at

$\sqrt{s_{NN}} = 4 \div 11$ GeV (1 ÷ 4.5 GeV/u ion kinetic energy)

at $L_{average} = 1E27\ cm^{-2} \cdot s^{-1}$ (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:

$p\uparrow p\uparrow$ $\sqrt{s_{pp}} = 12 \div 27$ GeV (5 ÷ 12.6 GeV kinetic energy)

$d\uparrow d\uparrow$ $\sqrt{s_{NN}} = 4 \div 13.8$ GeV (2 ÷ 5.9 GeV/u ion kinetic energy)

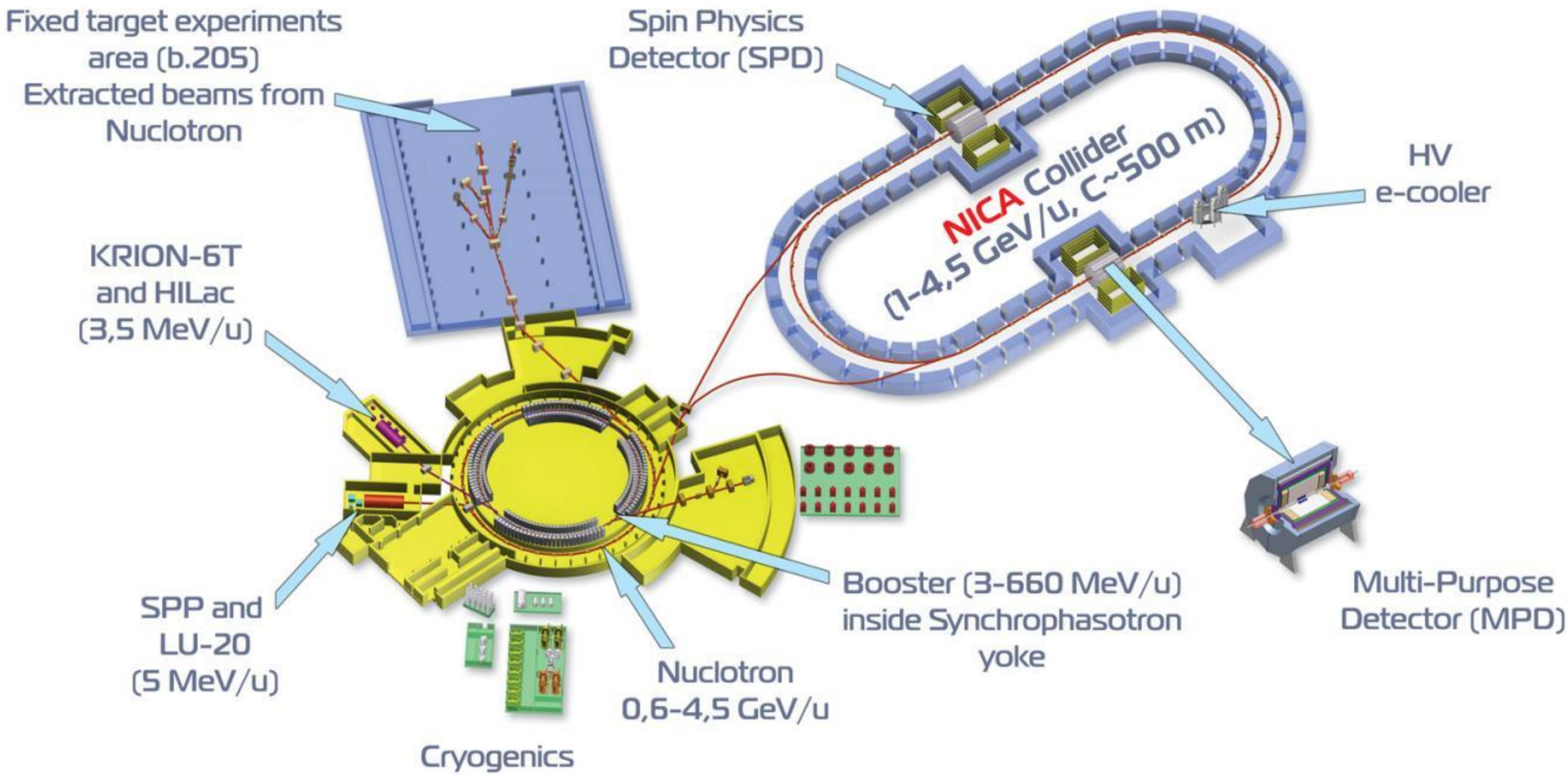
$L_{average} \geq 1E30\ cm^{-2} \cdot s^{-1}$ (at $\sqrt{s_{pp}} = 27$ GeV)

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

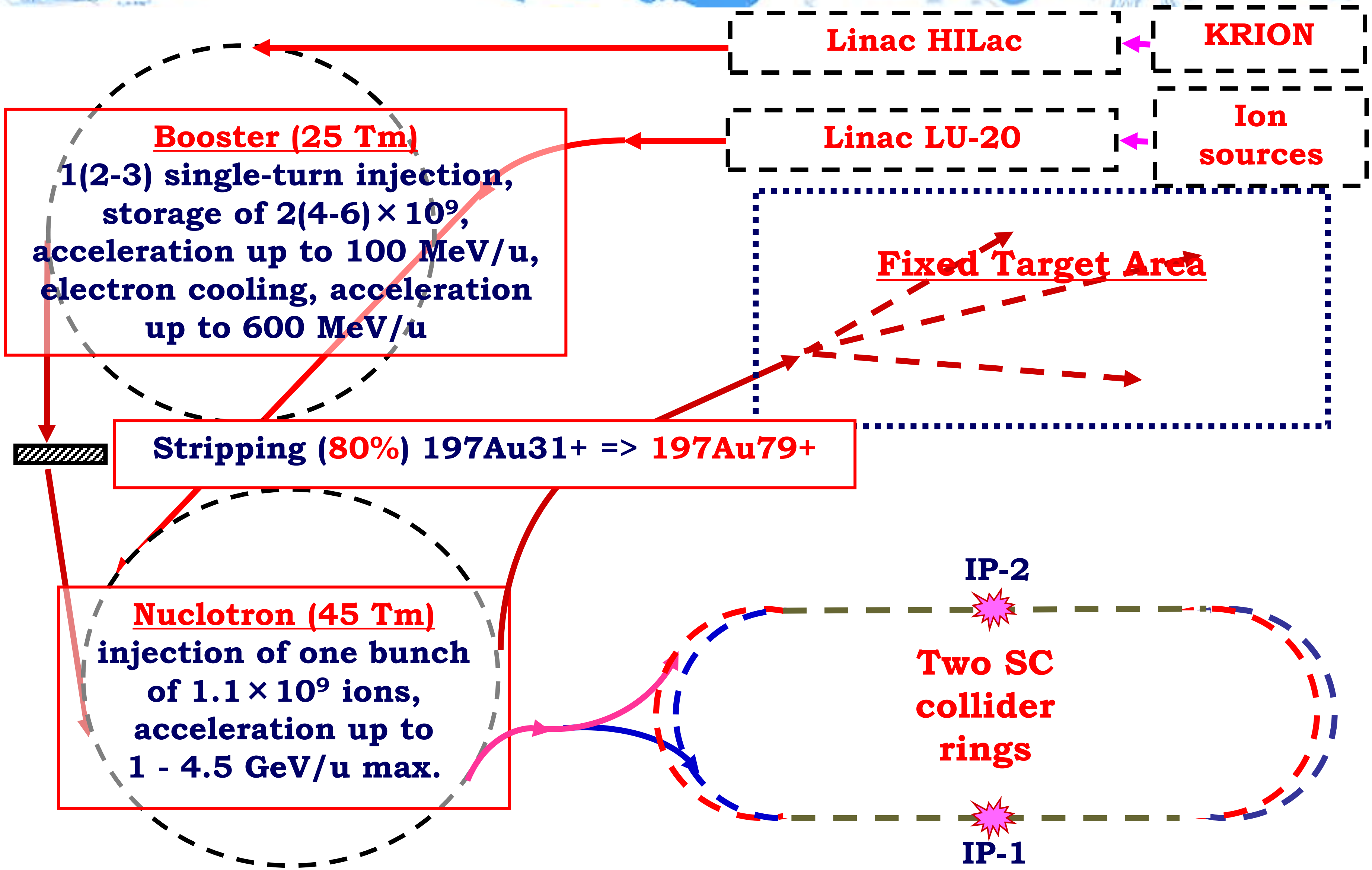
Li ÷ Au = 1 ÷ 4.5 GeV /u ion kinetic energy
p, $p\uparrow$ = 5 ÷ 12.6 GeV kinetic energy
d, $d\uparrow$ = 2 ÷ 5.9 GeV/u ion kinetic energy

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)

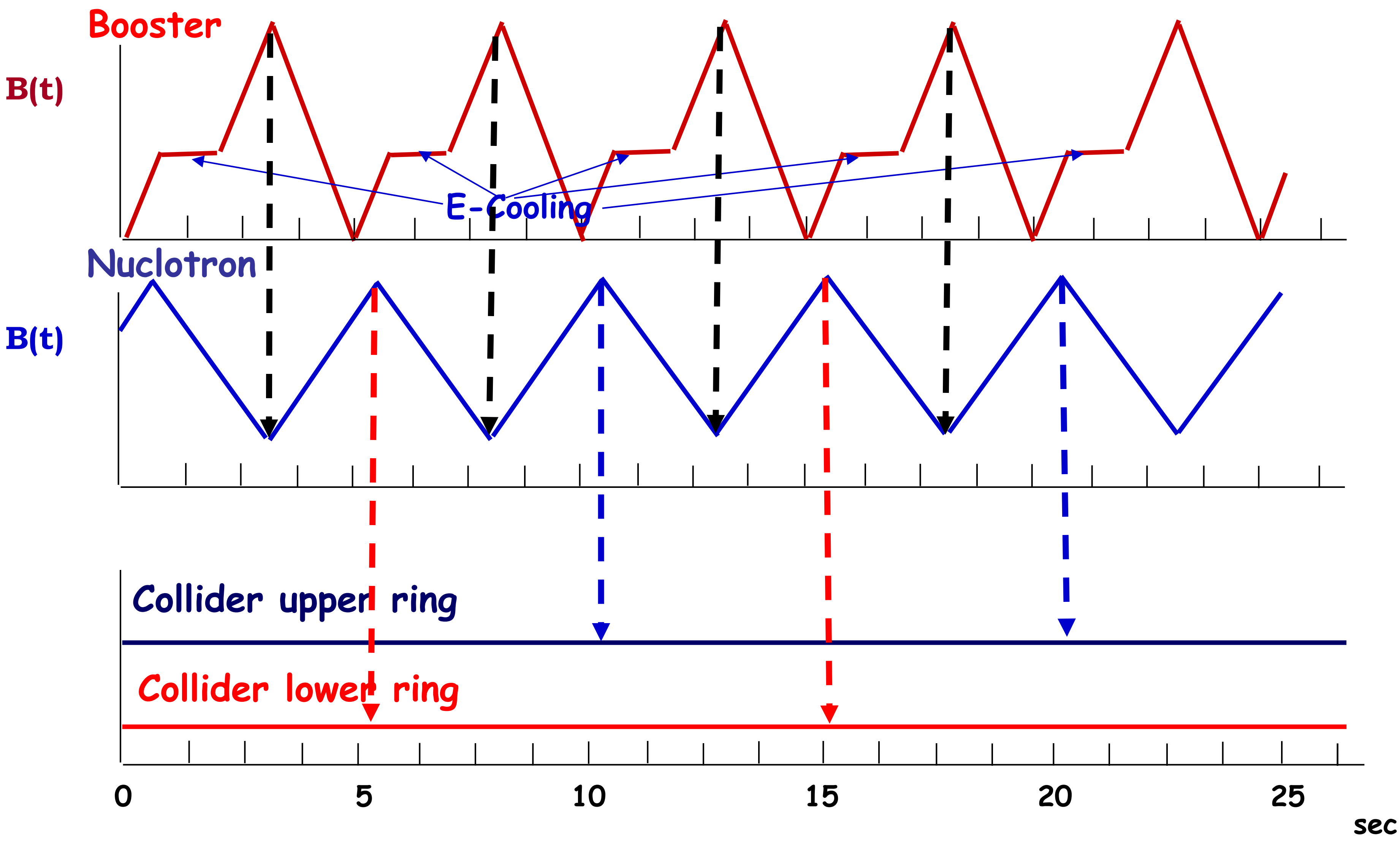
Superconducting accelerator complex NICA
(Nuclotron based Ion Collider fAcility)



Facility Scheme and Operation Scenario



Facility structure and operation regimes



Injection Chain and Beam Parameters

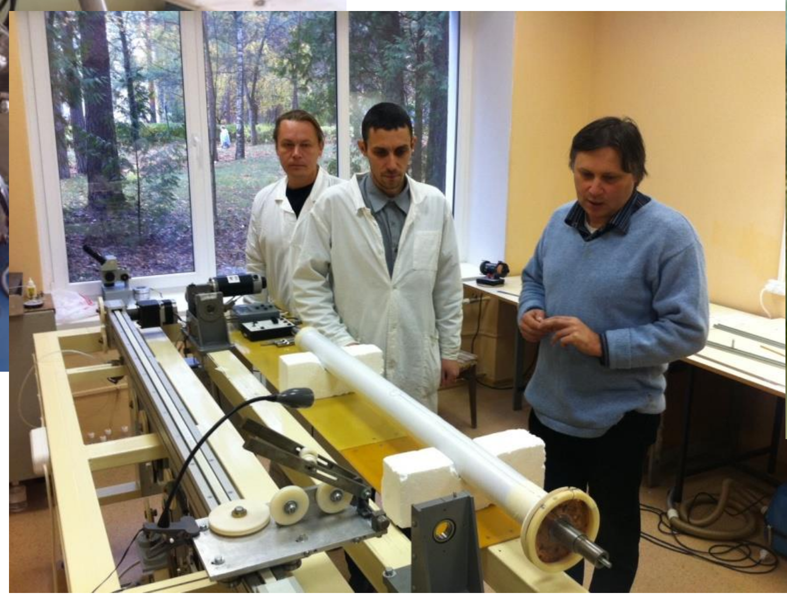
Acceleration stage	Energy, MeV/u	N, 10^9	ε, π mm mrad	σ_p	σ_s, m
Injection from HILac Acceleration in the Booster at 5-th harmonics	3.2	2	Depending of injection scheme		
After cooling in the Booster	65	1.5	0.73	$6.6 \cdot 10^{-5}$	C*
After acceleration in the Booster at 1-st harmonics	578	1.35	0.24	$3.1 \cdot 10^{-4}$	8.5
At injection into the Nuclotron	572	1.1	0.72	$4.1 \cdot 10^{-4}$	8.5
After acceleration in the Nuclotron	1000	1	0.55	$3.6 \cdot 10^{-4}$	8
	3000	1	0.24	$1.7 \cdot 10^{-4}$	8
	4500	1	0.18	$1.2 \cdot 10^{-4}$	8

* Coasting Beam

Heavy Ion Source KRION-6T

Assembling of electron/ion optics system: view from the “ion extraction” side.

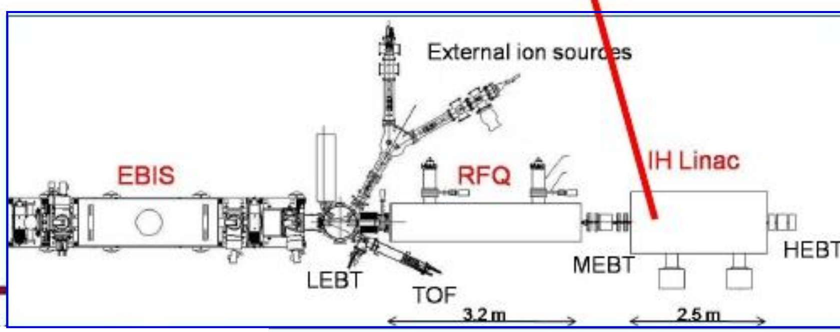
Solenoid magnetic field of 5.45 Tesla has reached during the test in November 2012



6T solenoid is under test now

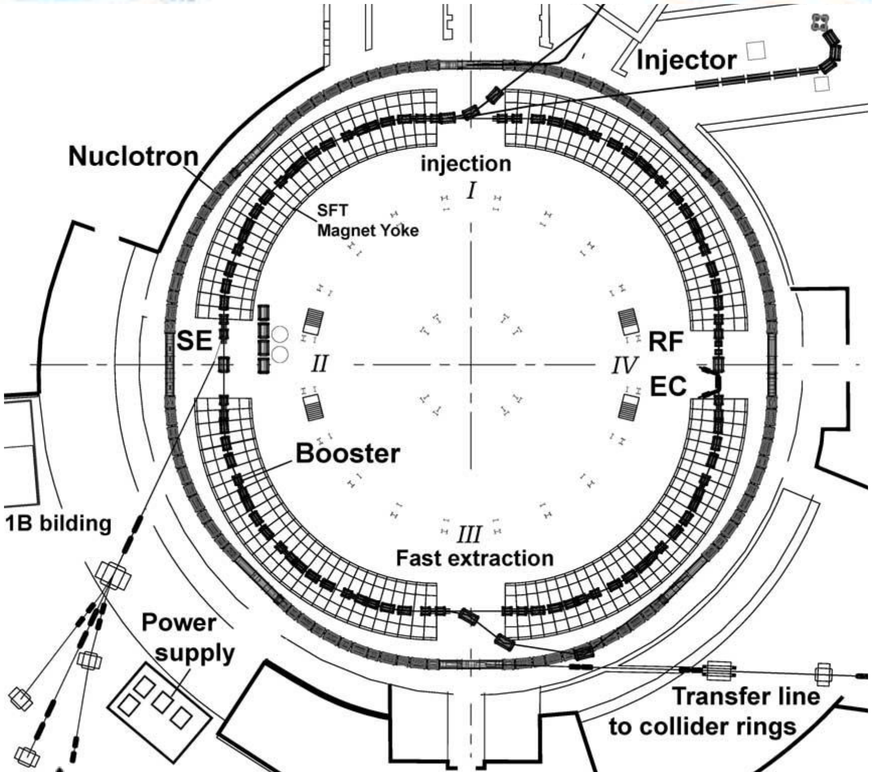
E.E.Donets
E.D.Donets

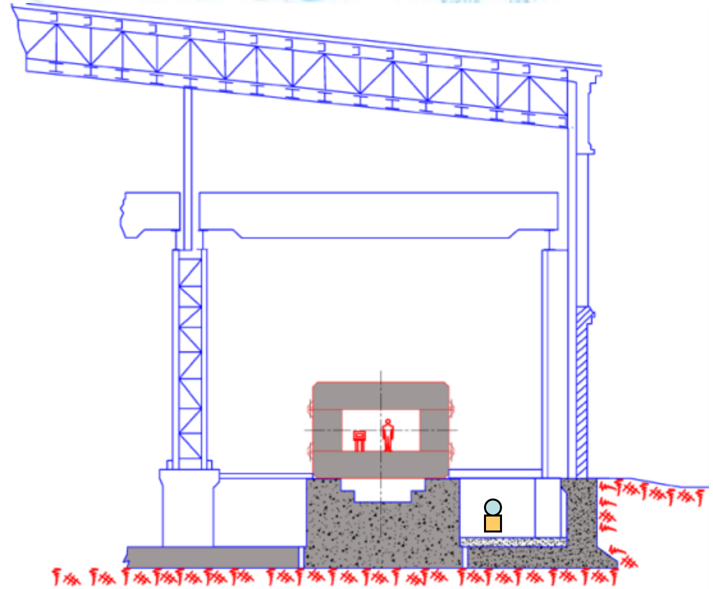
Heavy Ion LINAC (HILAC)

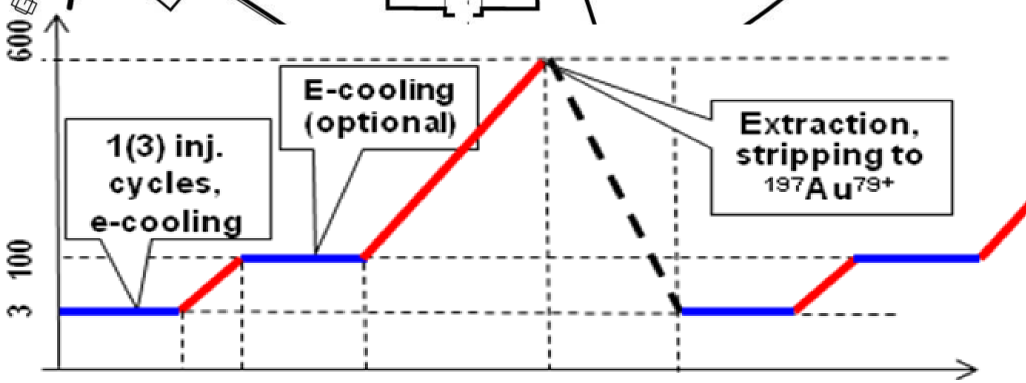


HILAC (3 MeV/u) delivery from BEVATECH (Frankfurt) is planned for April 2013.

Booster synchrotron, C=211 m

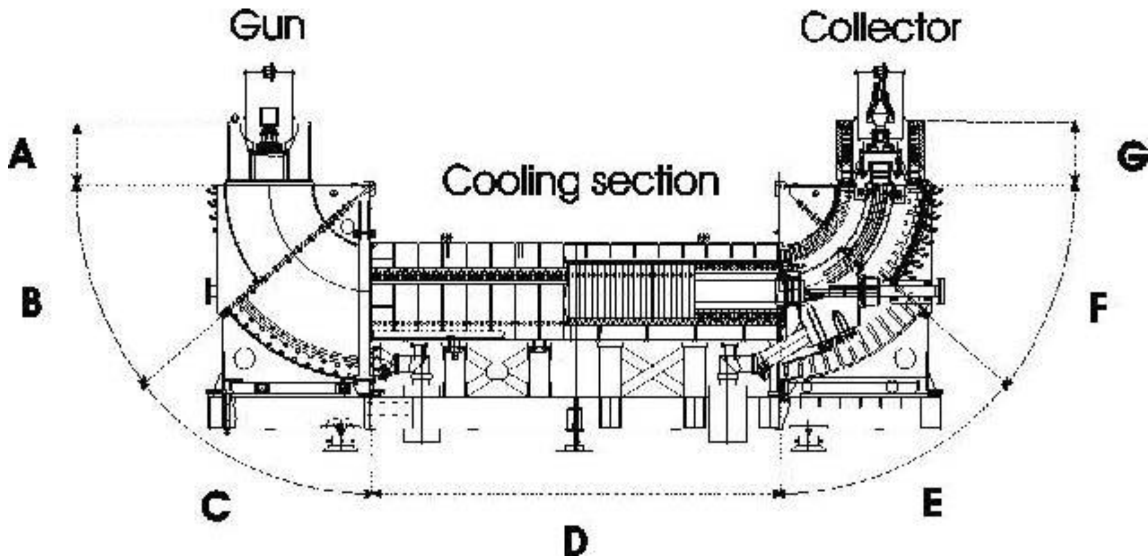






Electron cooling system for the Booster

CDR has been completed by BINP in 2012, beginning of technical design at BINP and manufacturing there - 2013



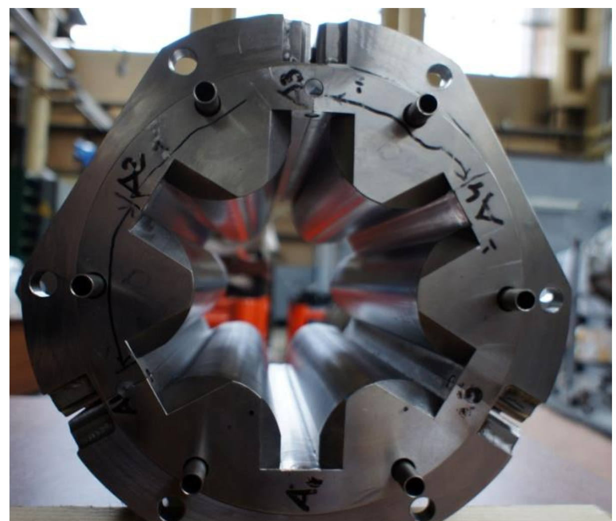
Agreement with Budker INP (Novosibirsk): common design, the main part will be constructed at BINP (V.Parkhomchuk and team)

Magnets for the Booster

Booster dipole at cryo-test (9690A) and magnetic measurements

Quadrupole lense at assembly for test

Cryogenic test-bench @ LHEP



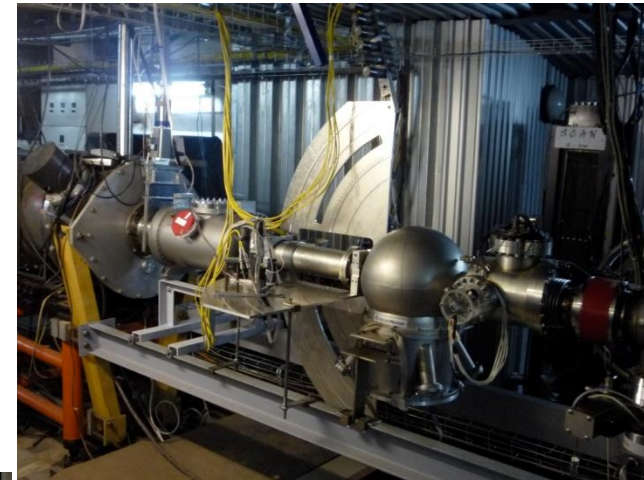
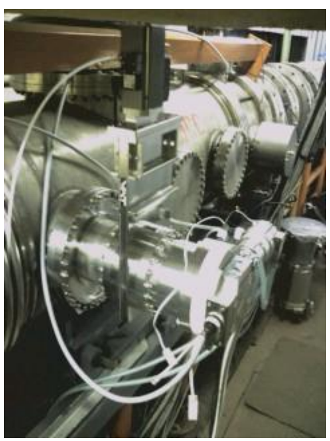
Sextupole corrector prototype (for SIS100 and NICA booster) at assembly

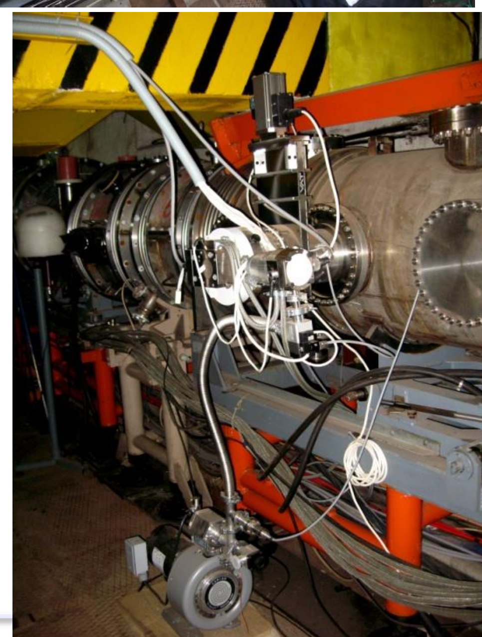
NICA: Nuclotron based Ion Collider fAcility

Nuclotron provides now performance of experiments on accelerated proton and ion beams (up to Fe24+, A=56, *now Xe42+, A=124*) with energies up to 6 AGeV (Z/A = 1/2)

Nuclotron upgrade

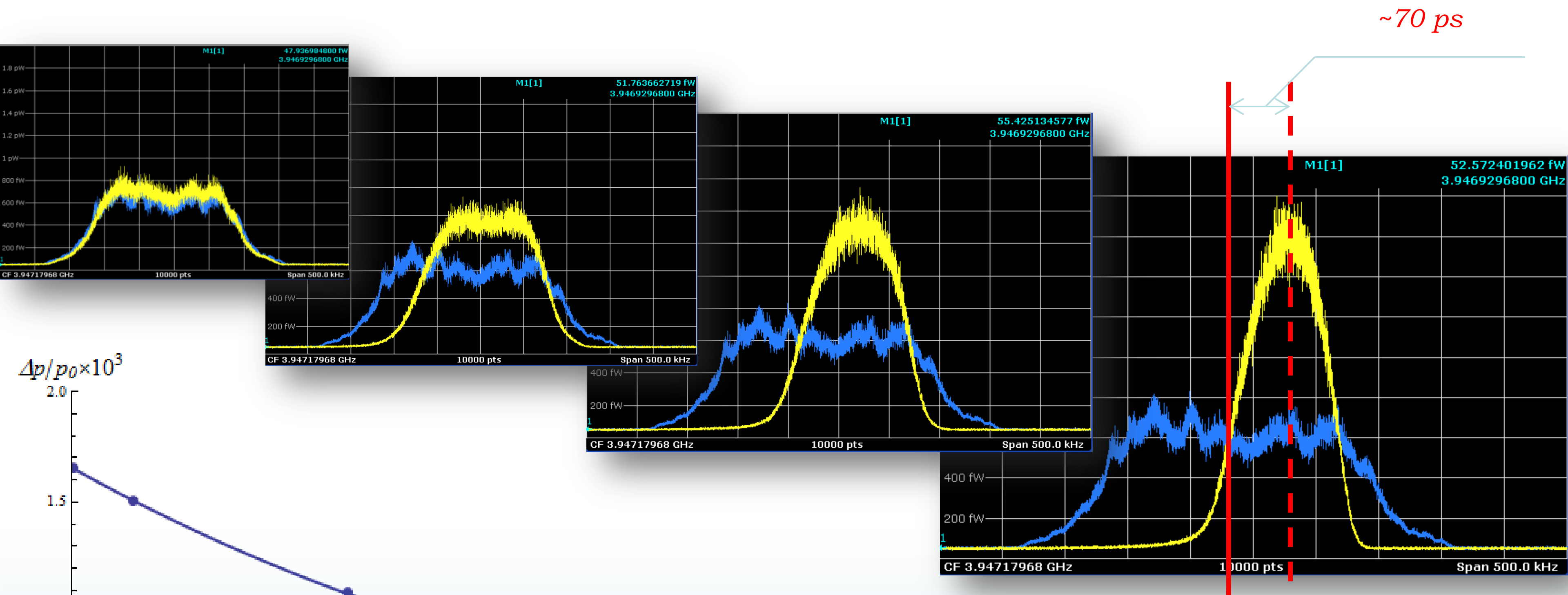


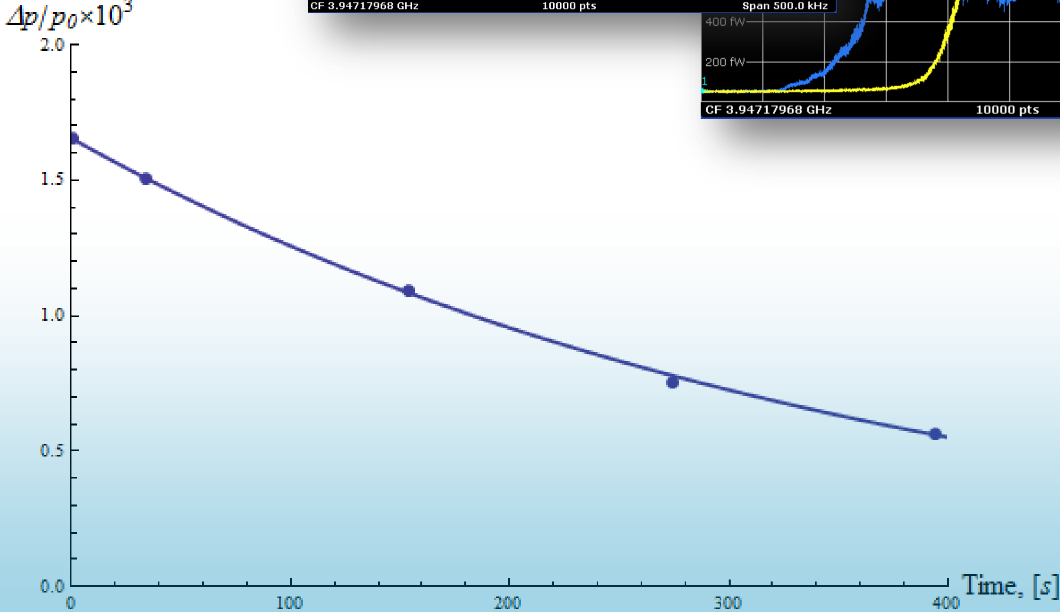






Stochastic Cool @ Nuclotron (March 2013)

Longitudinal cooling of coasting 3 GeV/u Deuteron beam

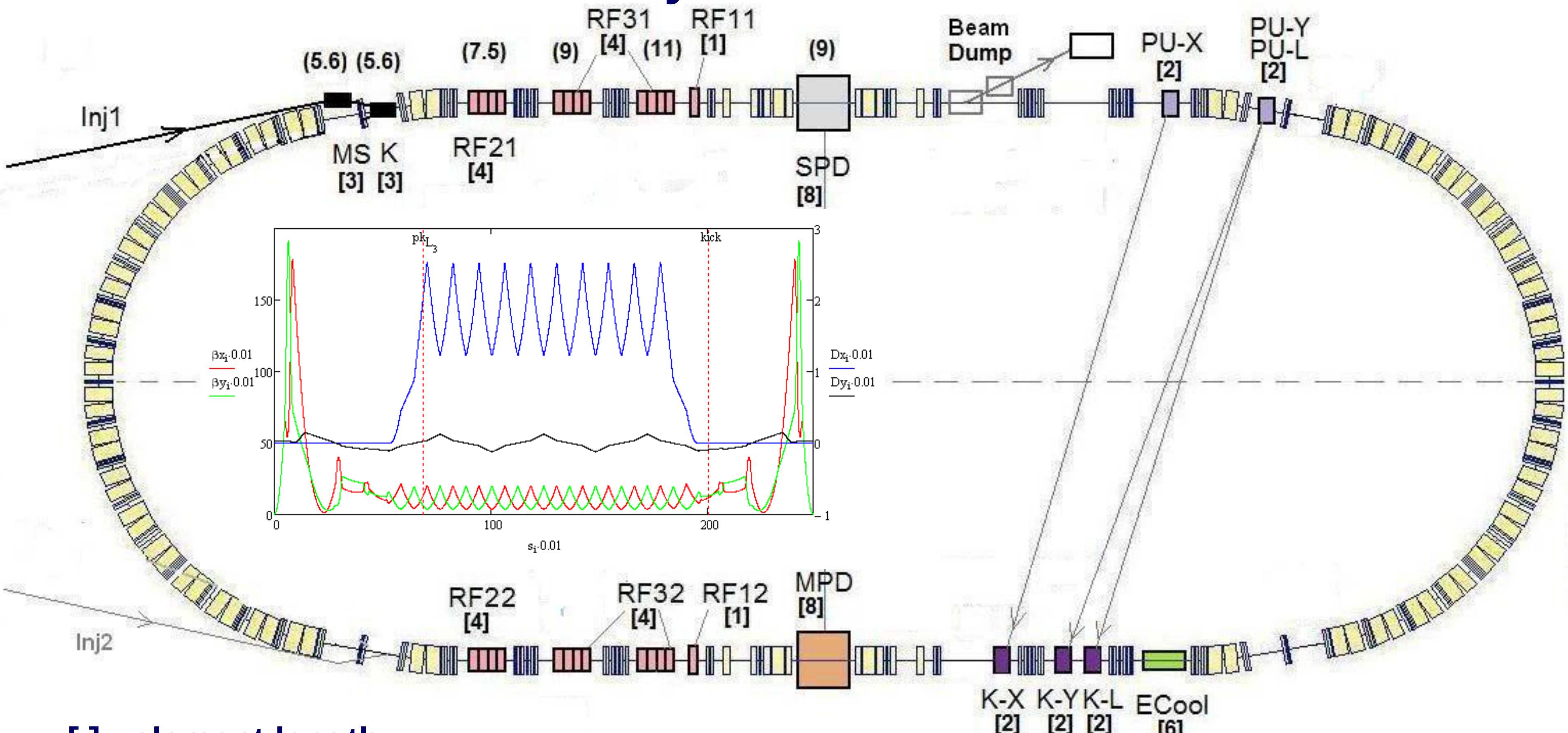




- The cooling time: *480s*
- dp/p (1e-3): *1.65 -> 0.56*
- τ_0 ~*365 s*

NICA collider

Heavy ion mode



[ ] - element length

( ) - distance between elements

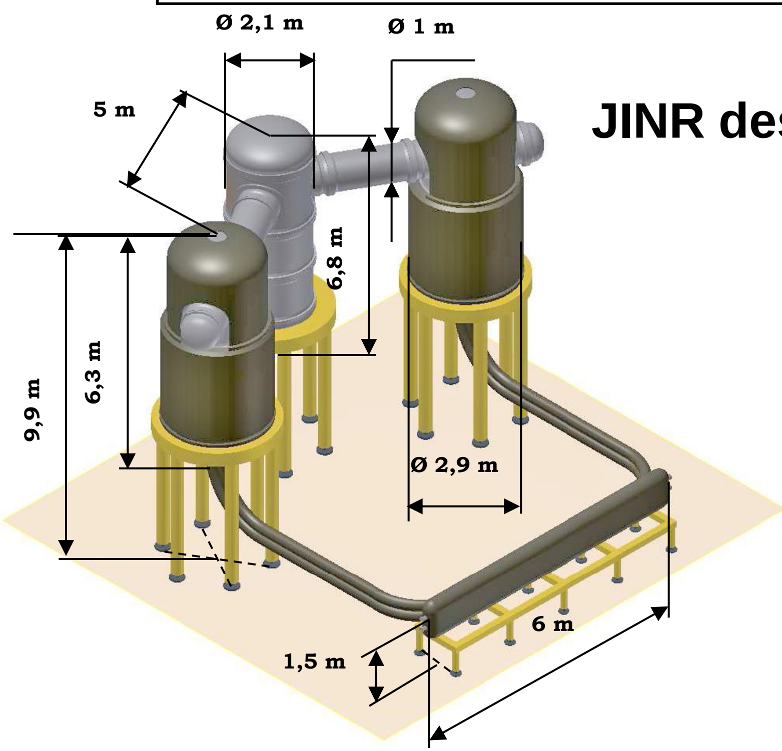
Au(+79) ion mode

Au - Au collisions

Circumference, m	503,04		
Bunch number	24		
R.m.s. bunch length, m	0.6		
Beta-function in IP, m	0.35		
Ion energy, GeV/u	1.0	3.0	4.5
Ion number per bunch	$2.75 \cdot 10^{8}$	$2.3 \cdot 10^{9}$	$2.2 \cdot 10^{9}$
R.m.s. momentum spread, 10^{-3}	0.62	1.25	1.65
R.m.s. emittance (hor/vert), $\pi \cdot$mm$\cdot$mrad	1.1/ 1.01	1.1/ 0.89	1.1/ 0.76
Luminosity, 10^{27} cm^{-2}s^{-1}	0.012	1	1
IBS growth time, s	186	702	2540

High voltage electron cooler

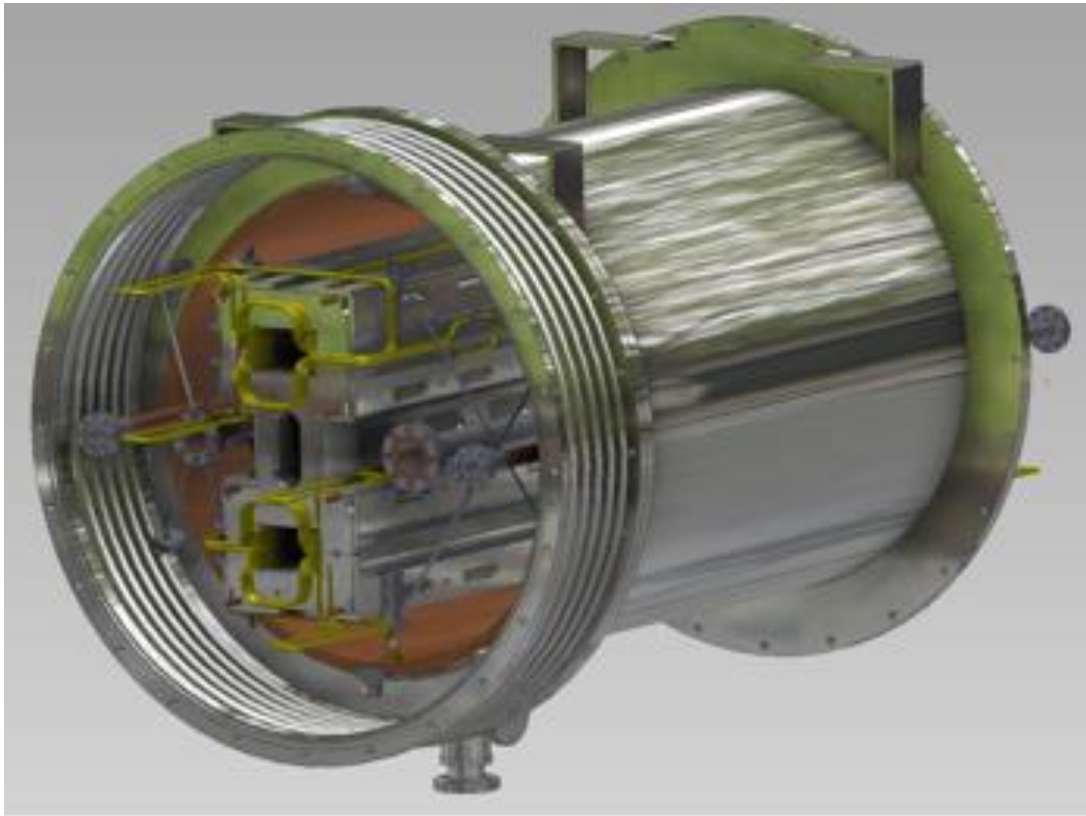
Maximum electron energy, MeV	2.5
Cooling section length, m	6.0
Electron beam current, A	0.5
Electron beam radius, cm	0.8
Magnetic field in the cooling section, T	0.2
Magnetic field imperfection in cooling section	2×10^{-5}
Longitudinal electron temperature, meV	5.0



JINR design

BINP design

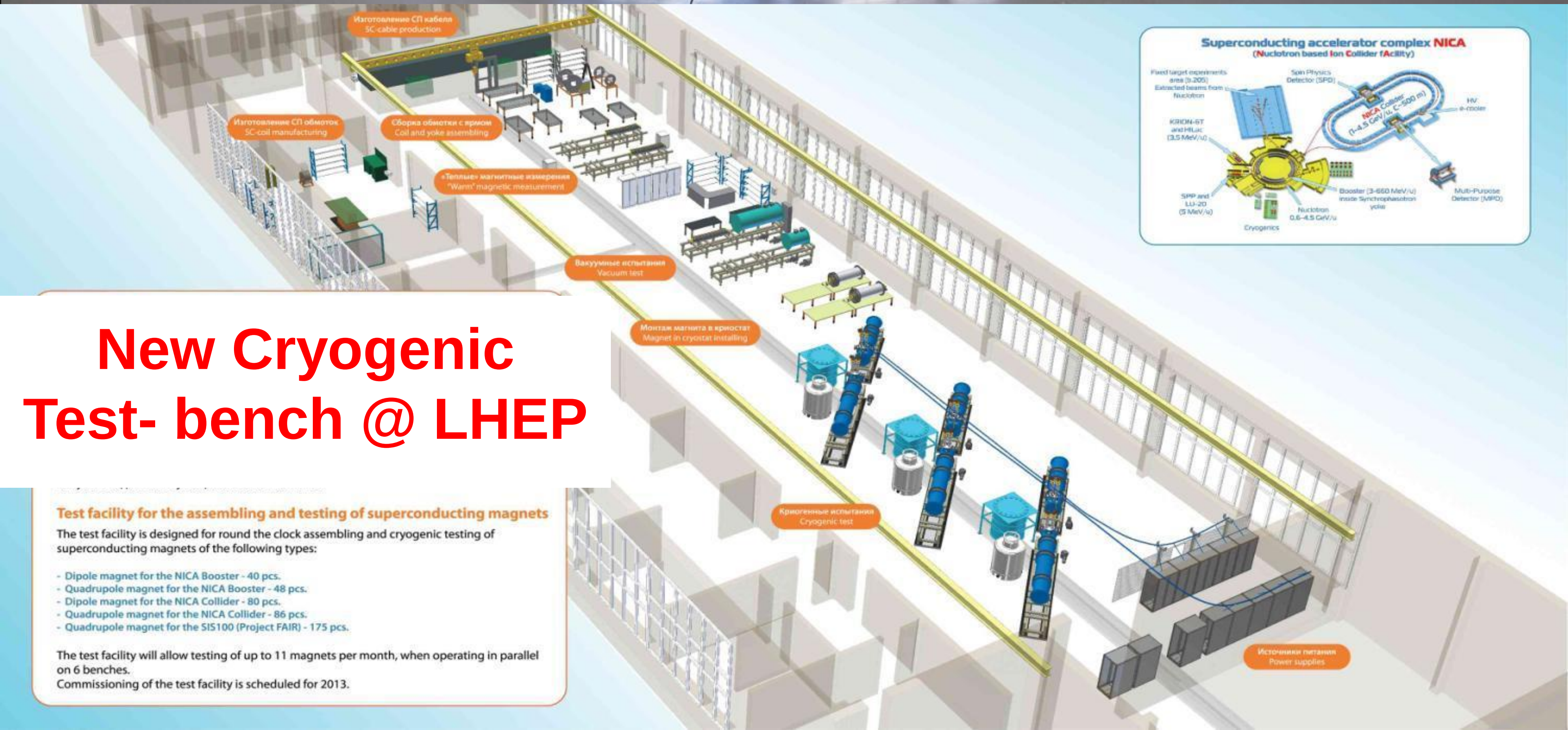
Collider magnets construction



B = 2T, I = 12 kA, G=6 kA/sec

under testing just now!

New Cryogenic Test- bench @ LHEP



Test facility for the assembling and testing of superconducting magnets

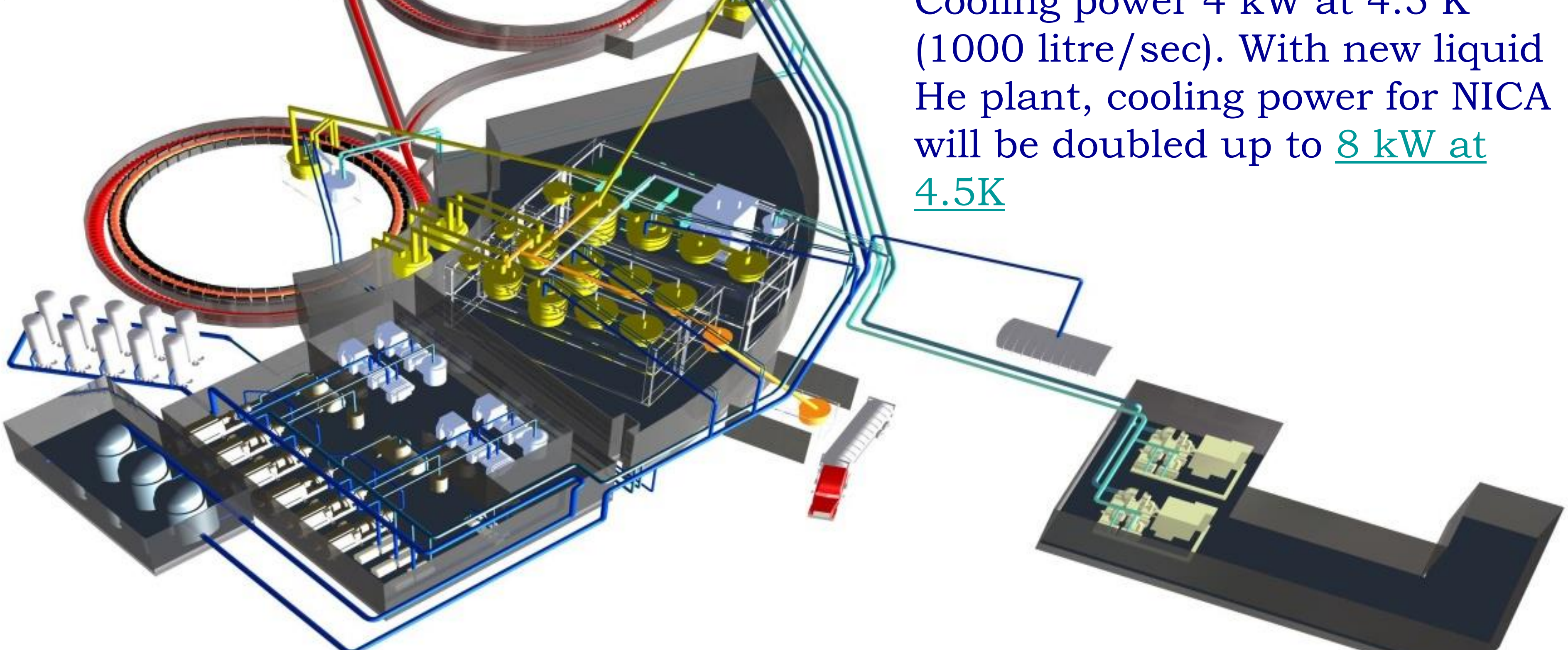
The test facility is designed for round the clock assembling and cryogenic testing of superconducting magnets of the following types:

- Dipole magnet for the NICA Booster - 40 pcs.
- Quadrupole magnet for the NICA Booster - 48 pcs.
- Dipole magnet for the NICA Collider - 80 pcs.
- Quadrupole magnet for the NICA Collider - 86 pcs.
- Quadrupole magnet for the SIS100 (Project FAIR) - 175 pcs.

The test facility will allow testing of up to 11 magnets per month, when operating in parallel on 6 benches.
Commissioning of the test facility is scheduled for 2013.

NICA Cryogenics

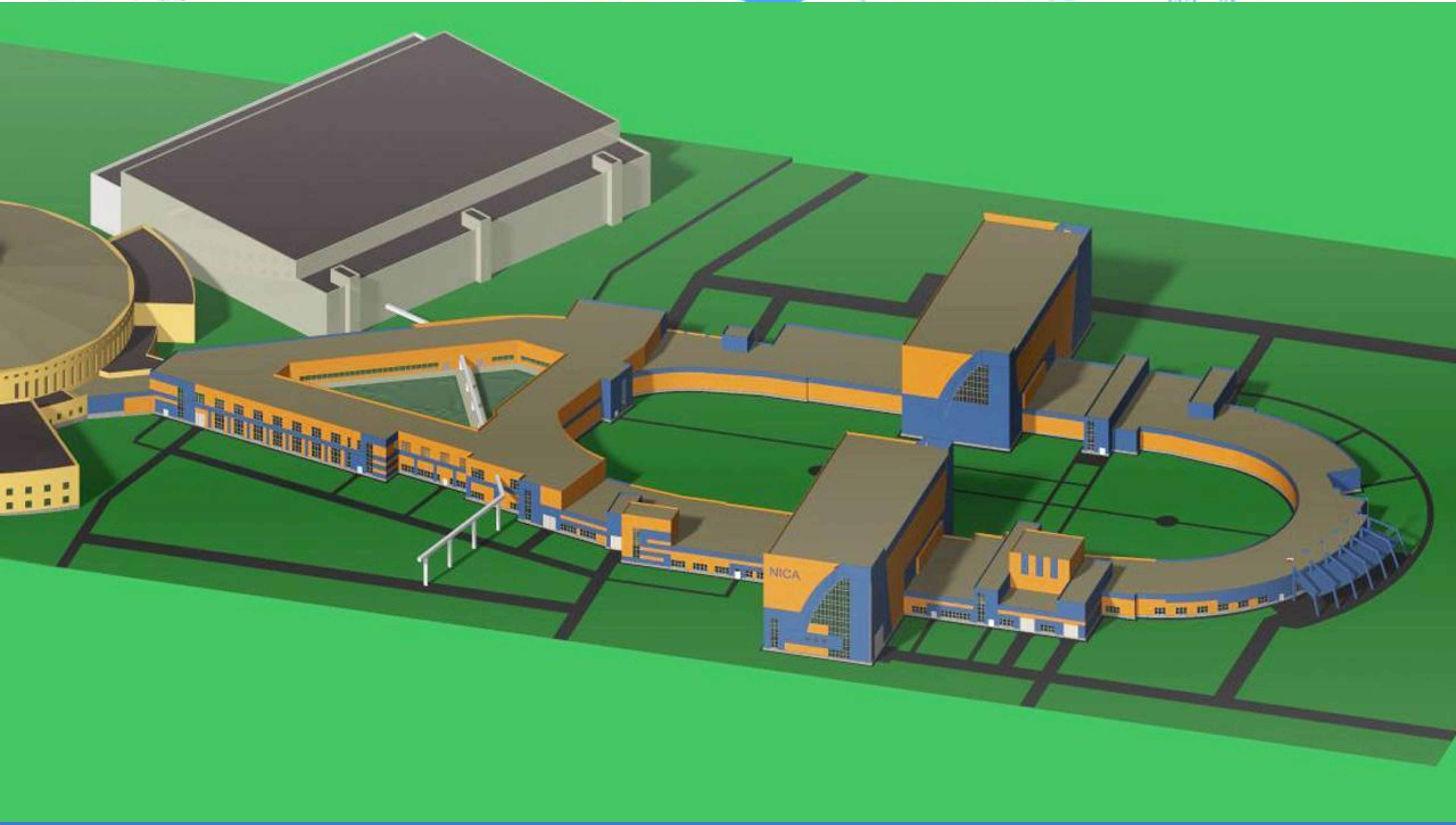
wet turboexpander
(300 000 terns/min)



LHEP has unique the most powerful He liquifier complex in Europe:

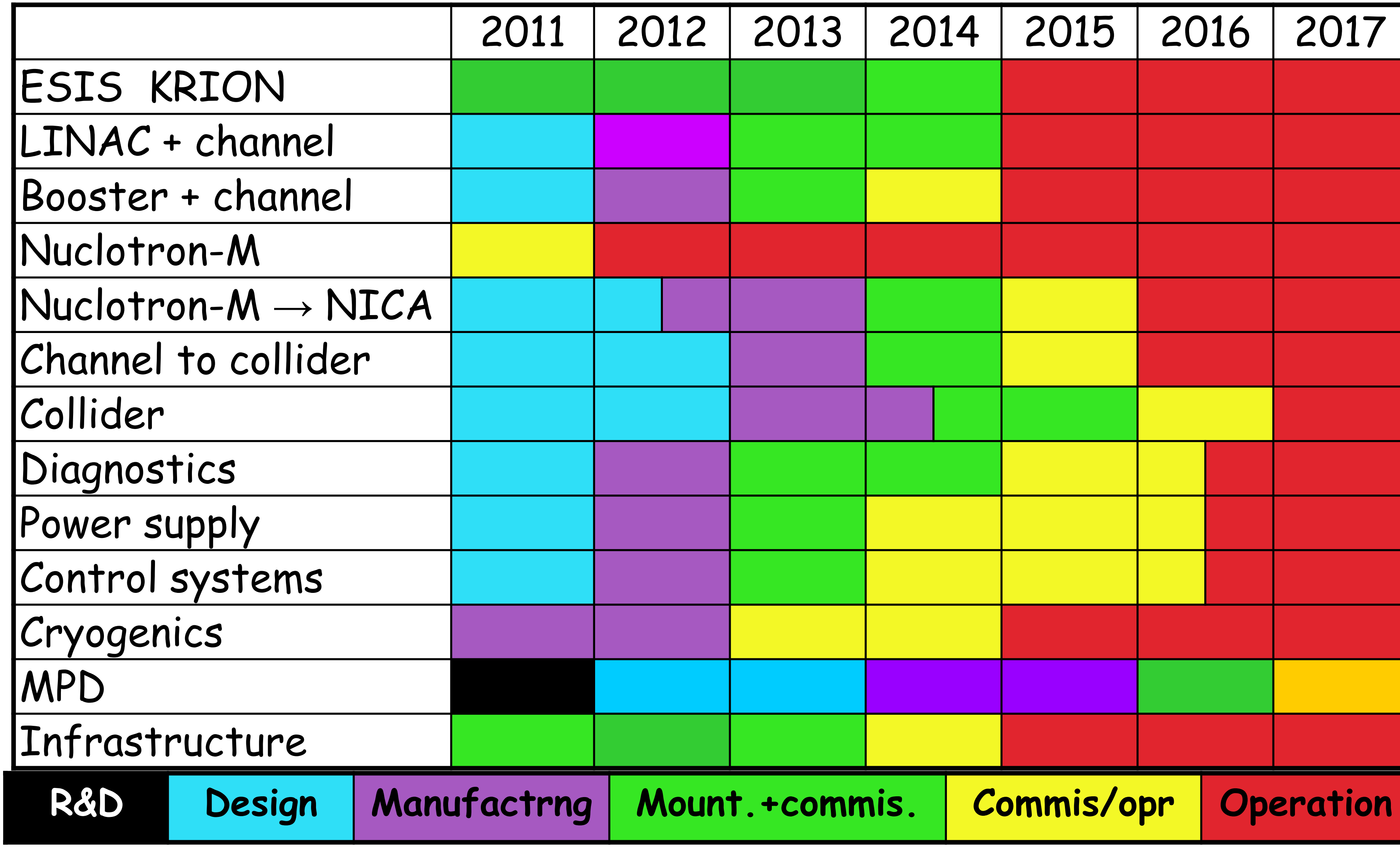
Cooling power 4 kW at 4.5 K (1000 litre/sec). With new liquid He plant, cooling power for NICA will be doubled up to 8 kW at 4.5K

NICA plan



ALL geological, geodetical, topography measurements and drillings had been fulfilled and analyzed. Technological part of the TDR (main equipment, engineering systems, etc), radiation and environmental safety, architecture had been fulfilled.

Project Time Table



Welcome to Dubna