Nuclotron-NICA

A.Sidorin, on behalf of the team

PP PAC, JINR, Dubna, 18 January 2020

Contents

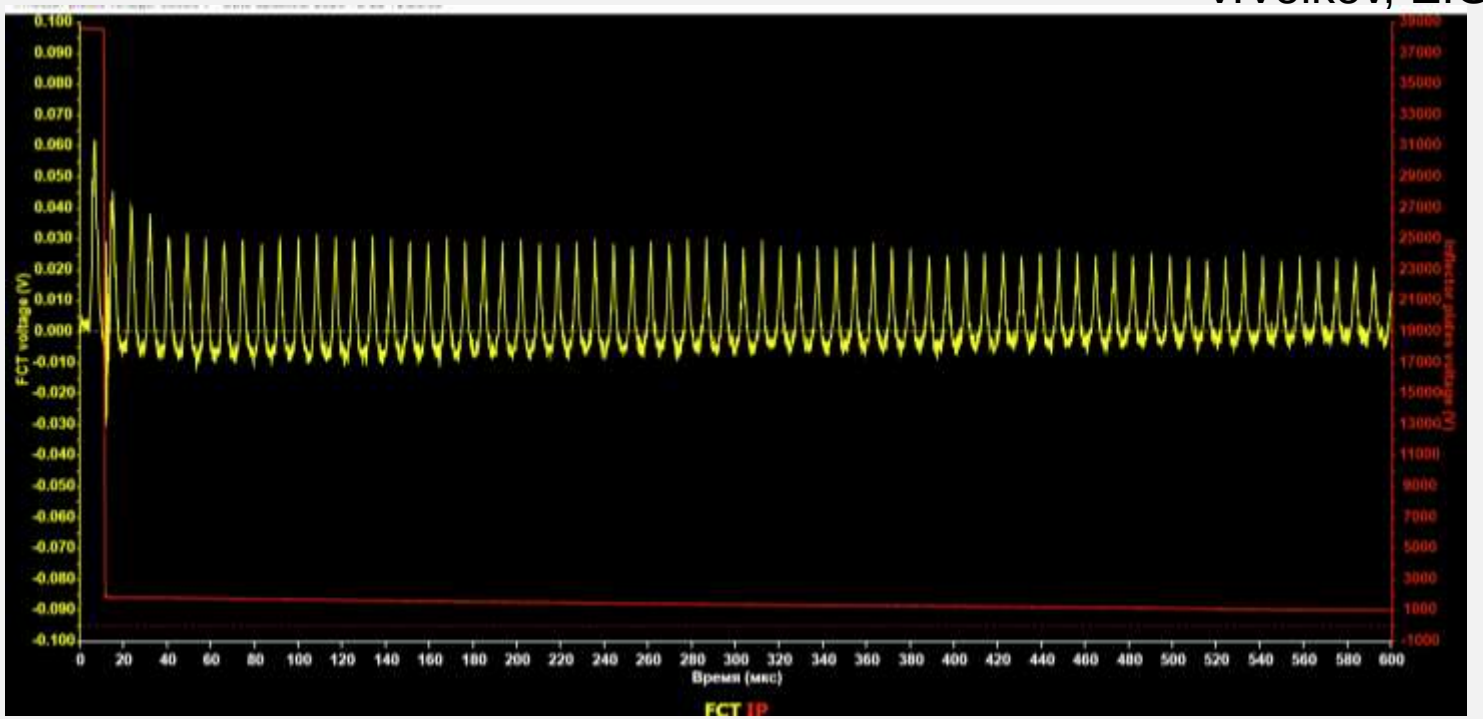
First run of the Booster operation

A.Alfeev

12.11 – 03.12: assembly and test of vacuum system
04.12 – 11.12: cooling, thermometry commissioning
12.12 – 18.12: commissioning of quench protection system, tuning of power supply, tuning of the HILAC – Booster transfer line
19.12: first circulating beam He^{1+}
19.12 – 30.12: test of beam diagnostics, beam acceleration, test of electron cooling, test of power supply, magnetic and cryogenic systems at design field

Fast current transformer

V.Volkov, E.Gorbachev

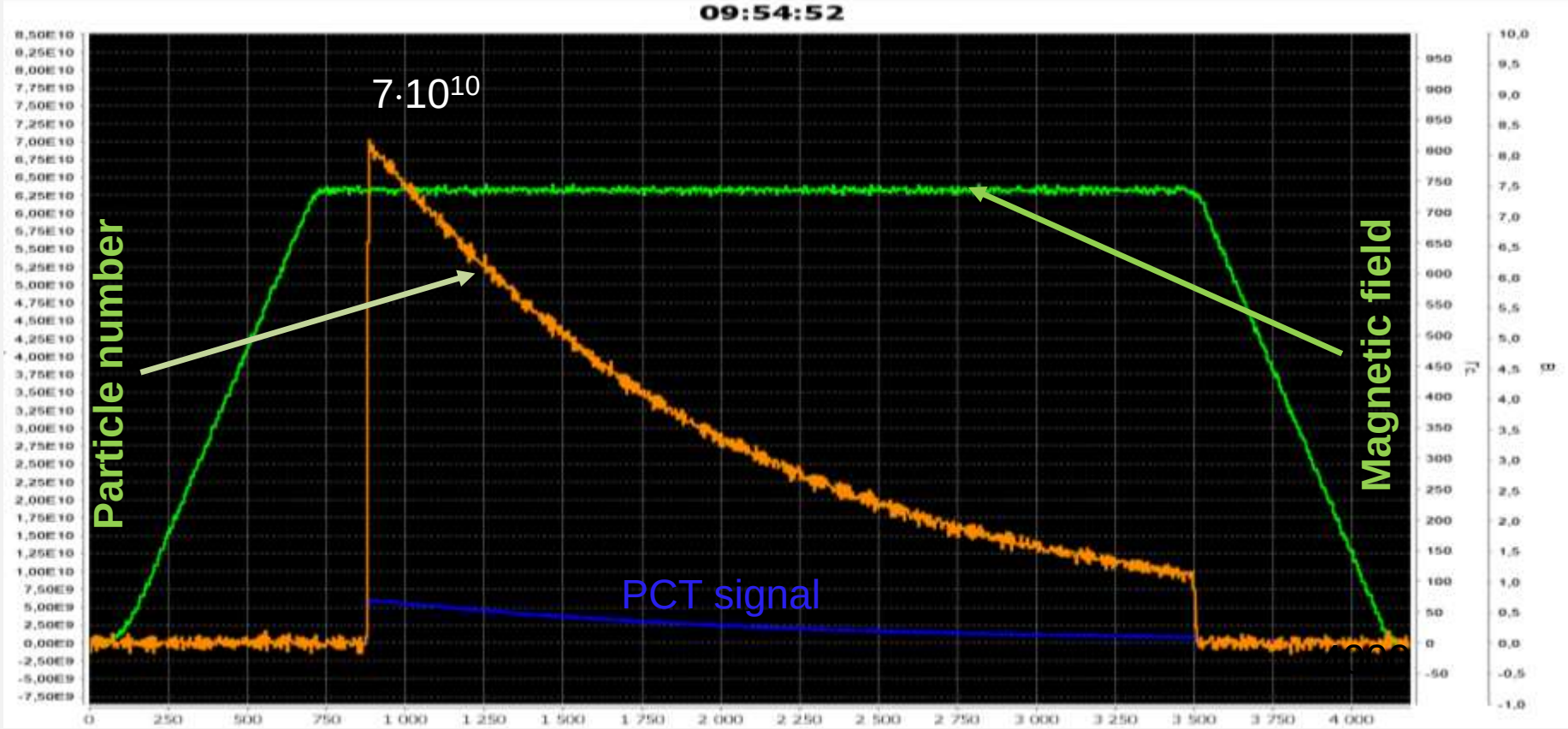


600 μs

Beam circulation

Parametric current transformer

V.Volkov, V.Andreev

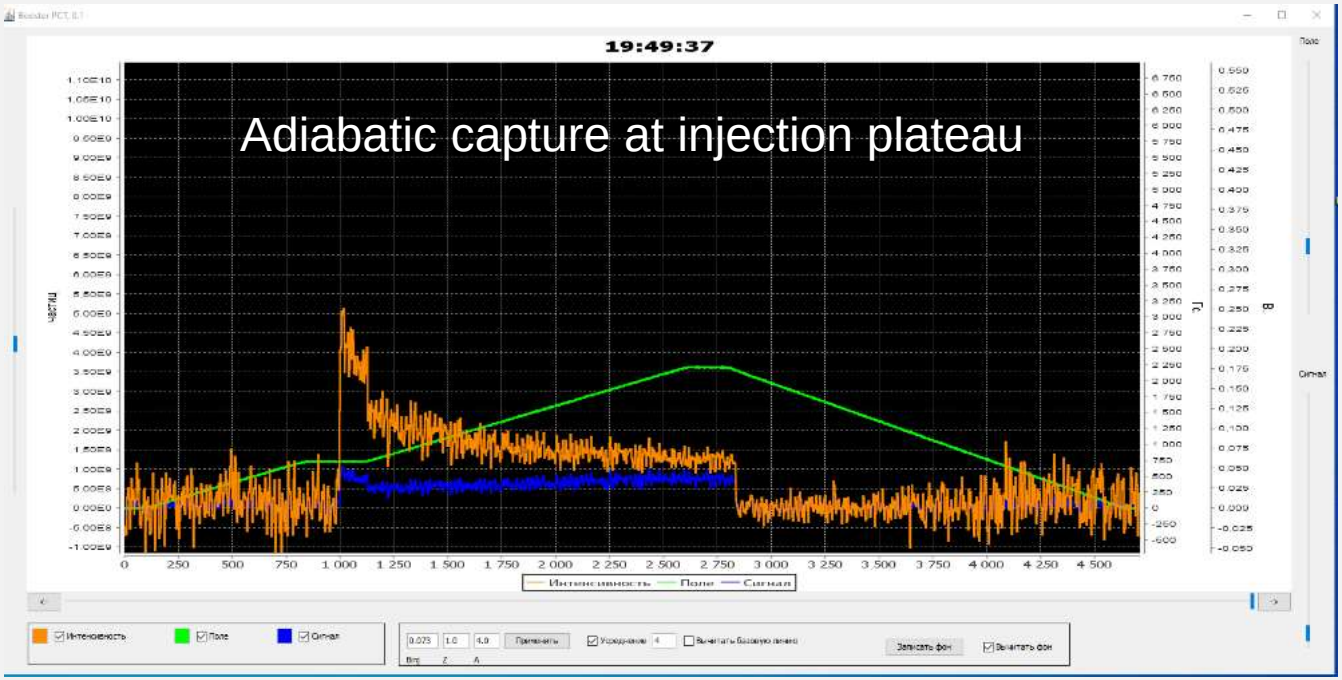


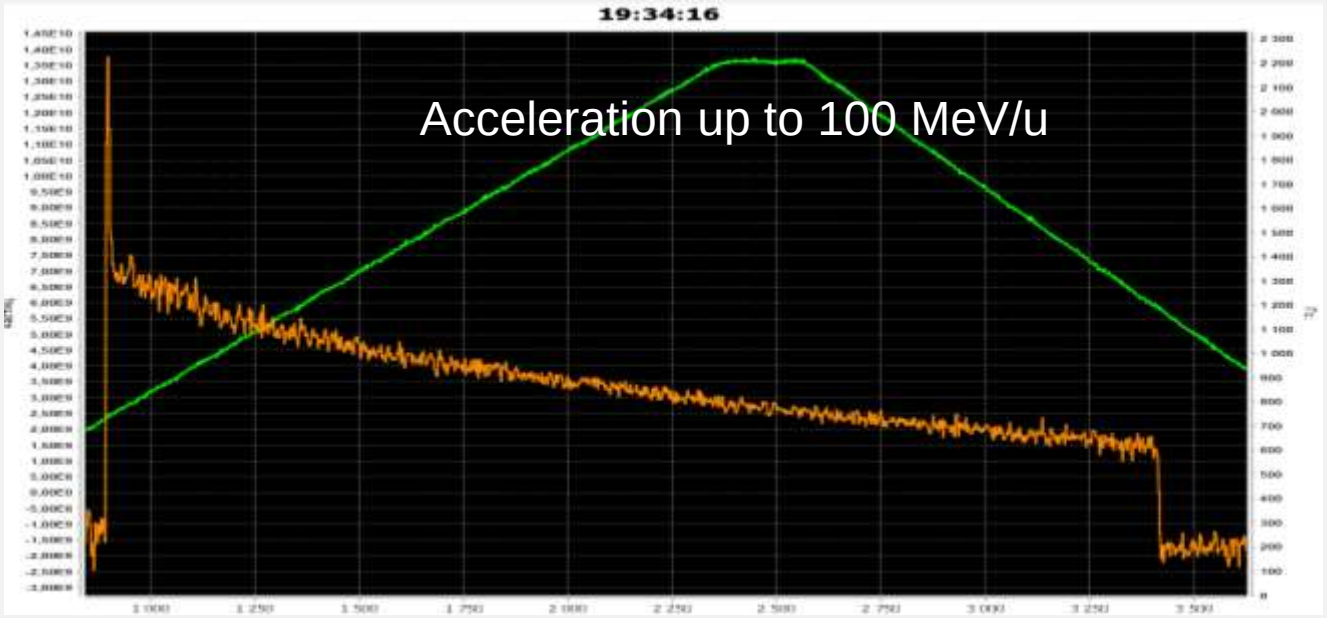
$7 \cdot 10^{10}$ elementary charges ~ $2 \cdot 10^{9}$ Au^{31+}

Life-time is about 2 s, equivalent pressure of residual gas is $3 \div 6 \cdot 10^{-8}$ Pa

Beam acceleration

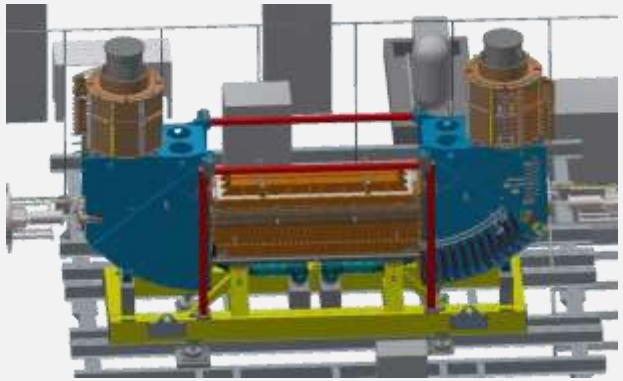
O.Brovko





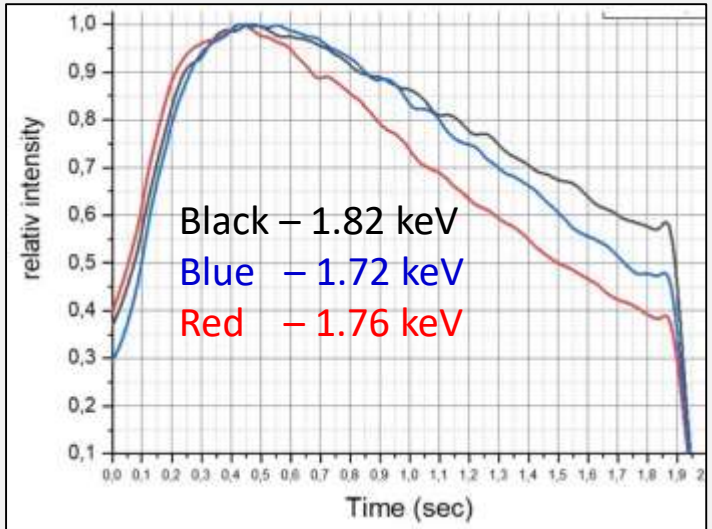
Electron cooling system

I.Meshkov, A.Kobets



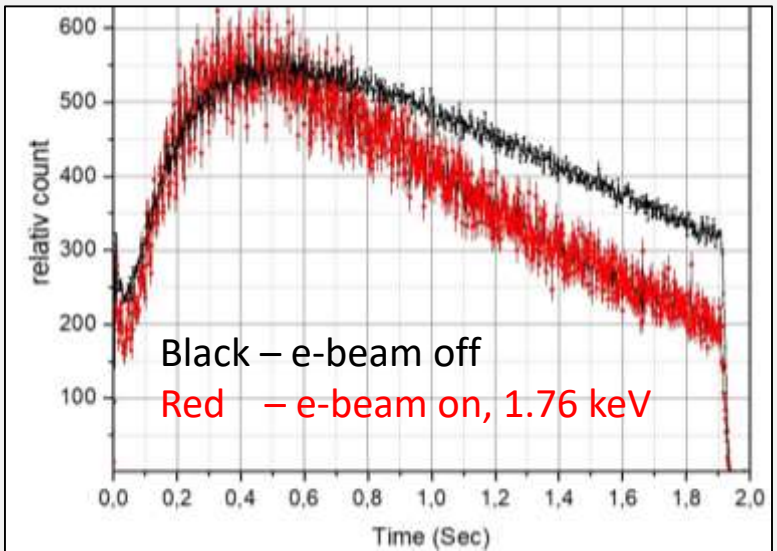
Operation at injection energy

Solenoid magnetic field 700 Gs
Electron beam current 150 mA
Optimal electron energy 1.76 keV
Residual gas pressure $4 \cdot 10^{-8}$ Pa



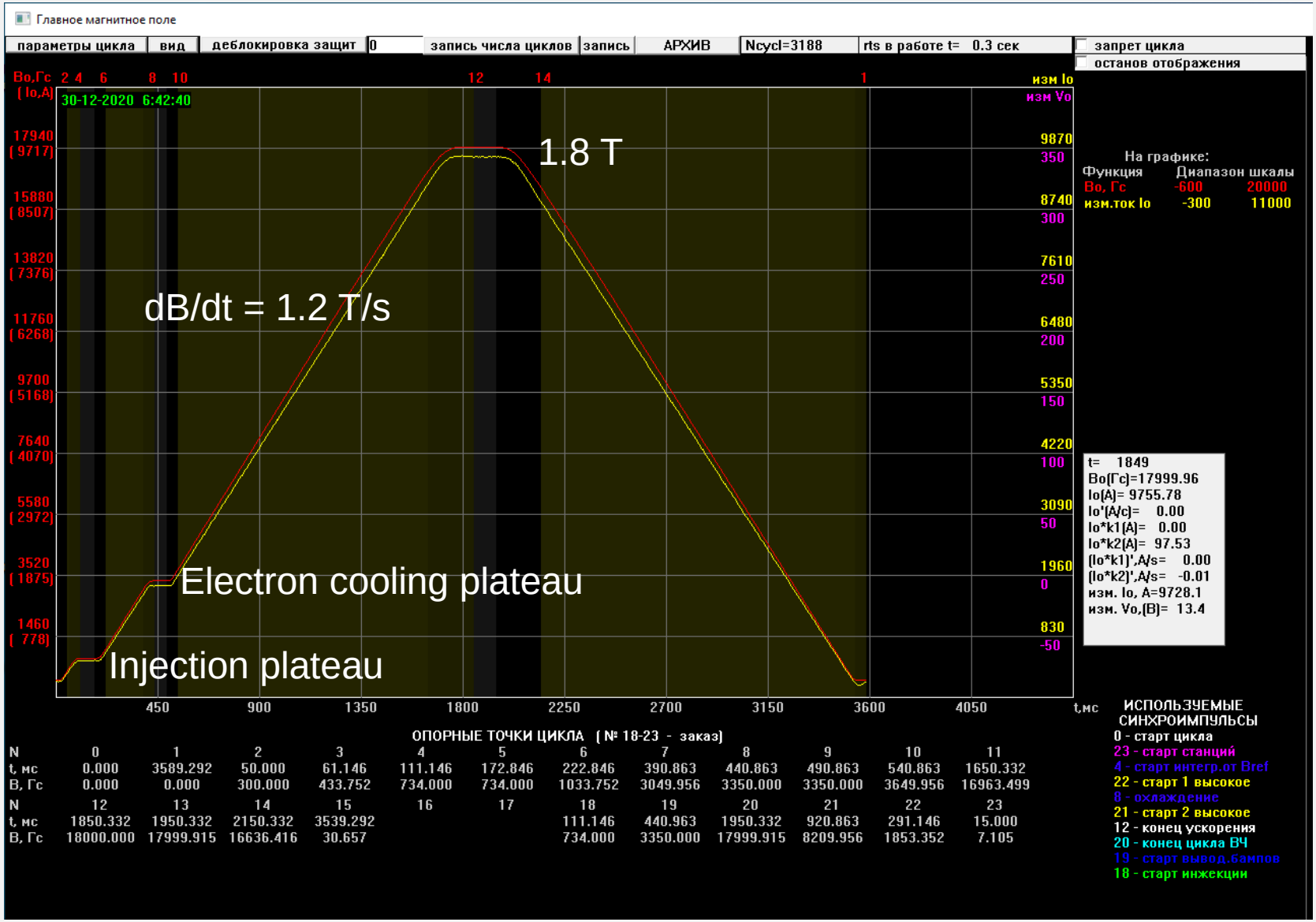
A.Baldin Ionization profilometer

Action of the electron beam leads to decrease of the ion beam life-time due to ion-electron recombination



Design magnetic field cycle

H.Khodzhibagiyan, A.Butenko, V.Karpinsky



Main results of the Nuclotron-NICA project

In the period from 2011 to 2020:

- **Development of the ion sources,**
- **LU20 modernization,**
- **13 runs (#42 - #55) of the Nuclotron operation,**
- **The high-tech assembly and testing line of SC magnets was put into operation,**
- **All elements of the Booster cryo-magnetic system were fabricated and tested, serial production of the collider magnets is in progress,**
- **The heavy ion linear accelerator (HILAc) was manufactured and installed, and adjusted to the design parameters,**
- **The beam transport channel from HILAc to Booster has been created and tested,**
- **The Booster was constructed and tested with a beam.**

Development of the ion sources

E.D.Donets, E.E.Donets

The construction of KRION-6T was completed; the source was used in the Nuclotron run #50 to accelerate argon ions. During the run #55 a program of experiments with carbon, argon and krypton beams was carried out

V.Fimushkin

The construction of SPI was completed, two runs were carried out as part of the research program with polarized deuteron beams, for the first time at the Nuclotron an acceleration of a polarized proton beam was provided

New laser and new plasma sources were created and used in the HILAC, Nuclotron and Booster runs

V.Monchinsky

LU20 modernization

May 2016. Commissioning of the modernized injection complex based on LU-20

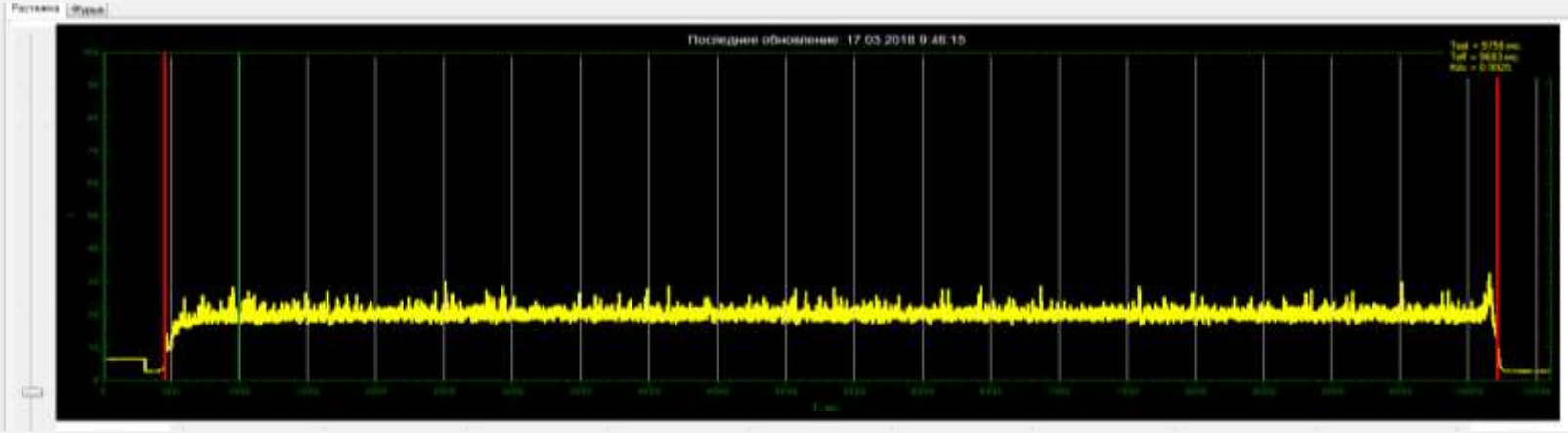
Results of the Nuclotron operation

- the capabilities of the complex for the implementation of the current physical program have been significantly improved;

- the maximum design beam energy has been reached;

- adiabatic beam capture into the acceleration mode is routinely used;

- the combined slow extraction mode has been worked out, the required quality of the extracted beam spill was provided for beams of extremely low intensity



March 2018. Time-dependence of the extracted beam intensity during the slow extraction: ^{78}Kr ions, the energy is 2.8 GeV/u, intensity is $2*10^5$ ions, the spill duration is T_{spill} = 10 s, direct current coefficient is k_{dc}= 99%.

The heavy ion linear accelerator

A.Butenko, A.Govorov

October 2016. Physical start-up of the HILAc – carbon beam was accelerated to the design energy.

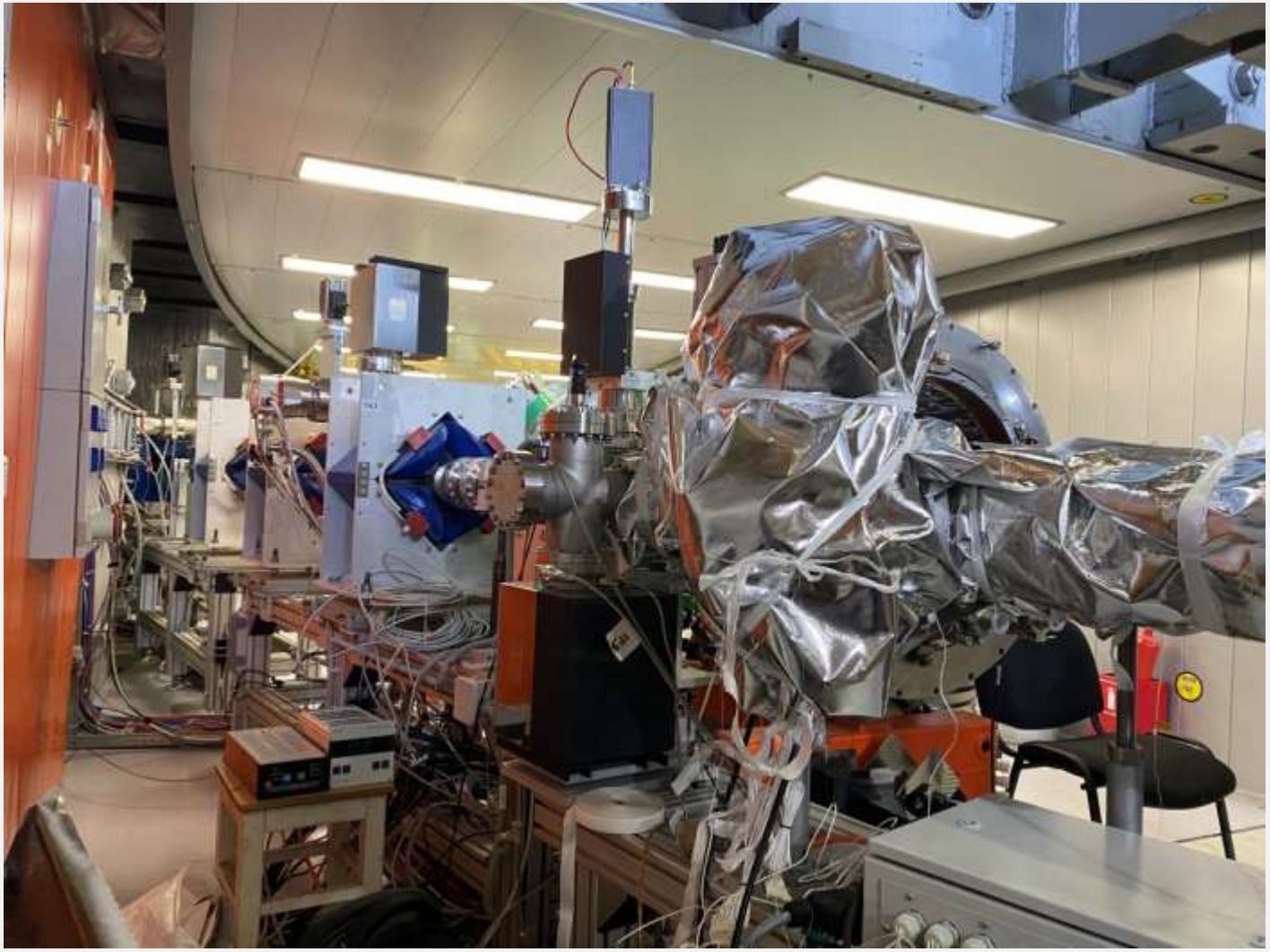
High-tech assembly and testing line of SC magnets

H.Khodzhibagiyan, A.Kostromin

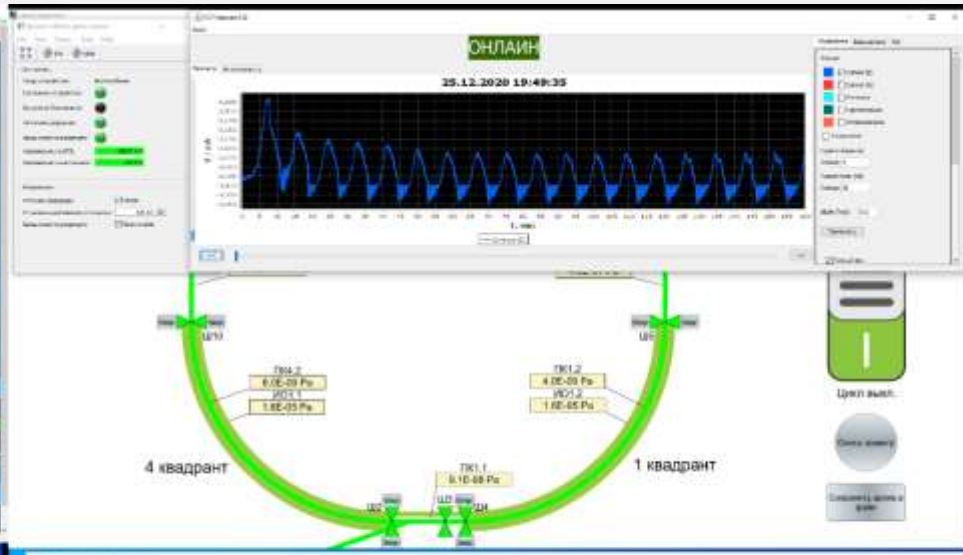
November 2016 – commissioning of the high-tech assembly and testing line of SC magnets for the NICA and FAIR projects.

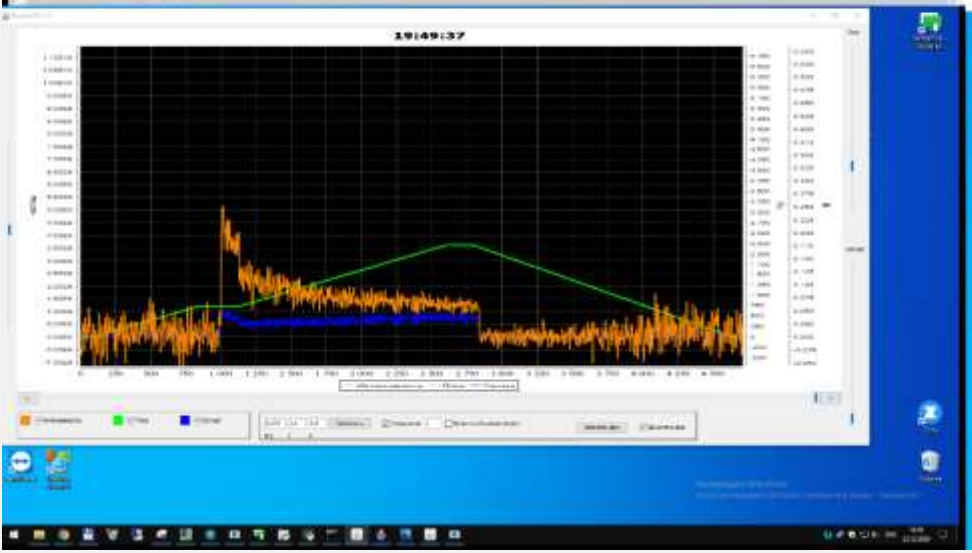
HILAC – Booster transfer line

A.Tuzikov



The Booster commissioning





Main goals of the project for 3 years (2021, 2022, and 2023):

- completion of the accelerator complex construction,
- carrying out commissioning works at the collider with the starting configuration of the equipment,
- completion of the construction of the collider in the basic configuration.

The main objects of the accelerator complex, which will be put into operation before the completion of the project:

- beam transport channel from Booster to Nuclotron,
- elements of the beam injection from the Booster and elements of beam extraction to collider, which have to be installed at the Nuclotron,
- beam transport channel from Nuclotron to collider,
- the collider in starting configuration,
- experimental stations and channels of extracted beams of the NICA complex (transport channels for heavy and light ions, polarized particles, test channel and the corresponding infrastructure),
- light ion linear accelerator LILAc,
- basic configuration of the collider.

Besides that, the development of the cryogenic complex has to be completed.

Creation of the accelerator complex elements in the period until 2023 is divided by the following main stages:

- Completion of the construction and commissioning of the new compressor station of the cryogenic complex – 2021.

- Development of the Nuclotron, creation of the required transport channels, performance of the fixed target experiments – 2021.

- Creation of the collider in starting configuration permitting to provide experiments with colliding ion beams up to Bi^{+83} at mean luminosity of $L = 5 \cdot 10^{25}$ см$^{-2}$ с$^{-1}$ in the energy range $\sqrt{s_{NN}} = 8 – 11$ GeV/u – 2022.

- Creation of the experimental stations and transport channels for the extracted beams (transport channels for heavy and light ions, polarized beams, test channel and required infrastructure) – 2023.

- Completion of the collider creation in the basic configuration - 2023.

- Commissioning of the light ion linear accelerator (LILAc) required for experiments with polarized beams - 2023.

The elements of the complex are created on the basis of:

TECHNICAL PROJECTOF THE OBJECT "NICA COMPLEX"
Section: TECHNICAL SPECIFICATION (PASSPORT)
OF THE "NICA COMPLEX"OBJECT

approved on December 28, 2018, available at the web-site:
https://nica.jinr.ru/documents/TDR_spec_Fin0_for_site_eng.pdf

In accordance with recommendations of the «NICA Cost & Schedule Review Committee» the Project Office was set up including the following groups with defined personal responsibilities:

schedule – A.S.Kostromin,
logistics – A.V.Slesarenko,
budget - V.V.Morozov,
safety – A.D.Kovalenko,
quality assurance – H.G.Khodzhibagiyan

The framework document “Milestones of the NICA realization during 2020-2022” developed by the office was approved by the project leadership and JINR directorate.

Funding profile and control of its realization are provided using specialized databases ADB2 and NICA EVM.

Form № 29

Project Expenditures

Construction of the NICA accelerator complex

(full title of the Project)

Consolidated clauses	Theme budget (thousand US dollars)			
	2021 year	2022 year	2023 year	**TOTAL** for 2021 – 2023 yy
Staff (cl. 1-3)	4970	6500	6600	18070
International cooperation (cl. 4)	200	300	300	700
Materials, R & D, construction (cl. 5, 6, 9, 10, 18, 19)	32950	13720	4220	50880
Energy and water consumption (cl. 7, 8)				
Capital and current repairs of buildings, construction & equipment (cl. 14)				
Operational costs (cl. 11-13, 15-17)	10	20	20	60
TOTAL	38130	20540	11140	69710
including				
Materials, equipment (cl. 5, 6)	11750	8920	3520	24190
Start-up and adjustment work (cl. 9, 10)	1100	800	700	2600
Design, building construction (cl. 18, 19)	20100	4000	0	24100

PROJECT HEAD

LABORATORY DIRECTOR

LABORATORY ECONOMIST. Морозов В.Г.

Progress in the collider construction & design

- Main elements of the magnetic optics of the Nuclotron-collider transport channel were fabricated, fabrication of the power supply system, beam diagnostics devices are in the final stage.
- Serial production of the collider cryo-magnetic system is in progress, 80% of the dipole magnets are fabricated and tested
- Two RF1 stations are constructed and transferred to JINR; construction of RF2 is in the final stage, prototypes of RF3 are tested,-
- Construction of the collider electron cooling system, construction of the Light Ion Linear Accelerator LILAc, Technical design of the SC energy storage have been started.

Thank you for attention