ISBN: 978-3-95450-197-7 doi:10.18429/JACoW-RUPAC2018-TUPSA22

COMMISSIONING OF ELECTRON COOLING SYSTEM OF NICA BOOSTER

A.V.Smirnov, L.V.Zinovyev, A.S.Sergeev, S.V.Semenov#, A.G.Kobets, A.A.Sidorin, E.A.Kulikov, S.Yu.Kolesnikov, Yu.A.Tumanova, Joint Institute for Nuclear Research, Dubna, 141980 Russia
V.V.Parckhomchuk, M.I.Bryzgunov, A.V.Bubley, V.B.Reva,
Budker Institute of Nuclear Physics, Novosibirsk, 630090 Russia

Abstract

At the NICA project, two electron cooling systems were planned at the booster and collider. The booster cooler will be used for the multiturn injection procedure and for the formation of necessary beam parameters before injection from the booster to Nuclotron. This article presents the status of the commissioning of the electron cooling system at the NICA booster. The electron cooling system was produced in BINP (Novosibirsk) and delivered to JINR (Dubna) last year [1]. This year the commissioning of the cooler was done for parameter of the injection energy of ions 3.2 GeV/u. In the nearest future it will test for the intermediate ion energy 100 GeV/u. Finally, the cooler should operates at both energy during one injection cycle.

COOLER PARAMETERS

In order to achieve the required beam parameters in NICA booster, an electron cooling system (ECS) was designed, which was manufactured at INP (Institute of Nuclear Physics, Novosibirsk) [2]. In 2017 the system was shipped to JINR and its assembly and commissioning have been started. The distinctive feature of the present system is that for the first time ever an electronic cooling method with a magnetized e-beam will be applied to the superconducting synchrotron, which imposes some additional requirements for the construction and start of ECS, which itself is at room temperature (Fig. 1).

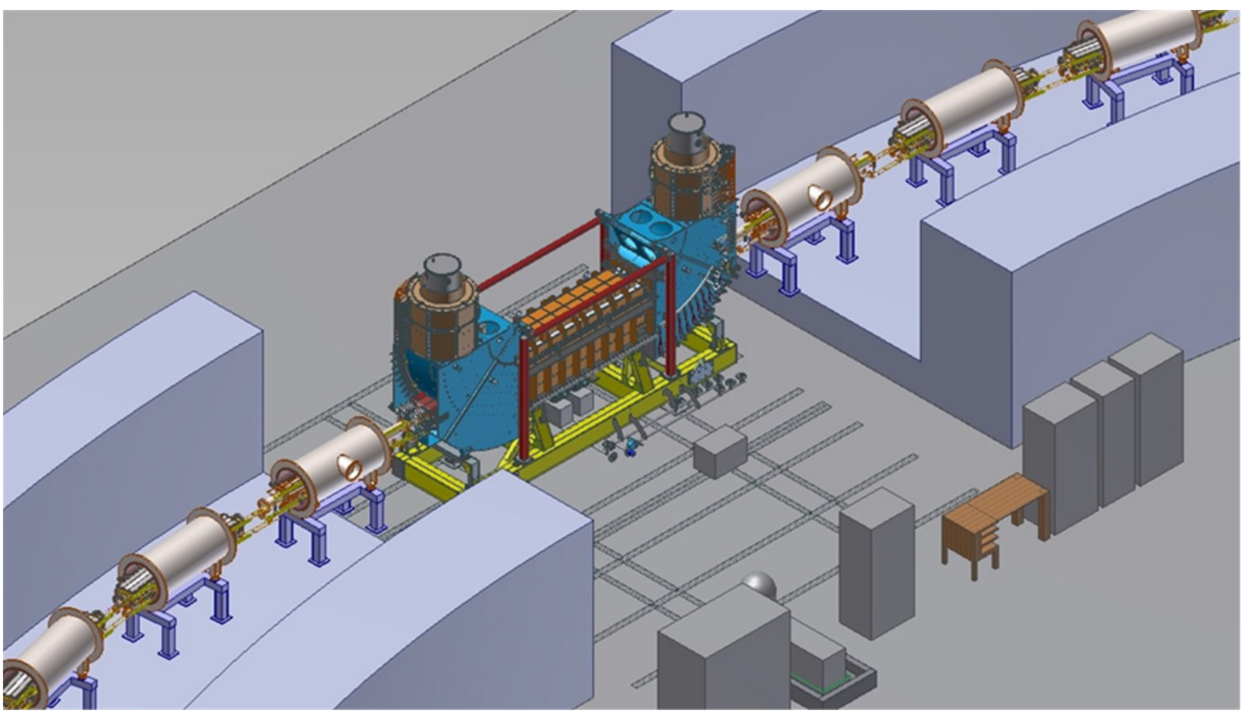

Figure 1: Electron cooling system in the booster.

The report describes the main steps of assembly and start of ECS directly in a straight booster section, which includes: MEP installation (water, electricity, air, oil system), geodetic works on putting the system on site. The measuring data of magnetic field uniformity of forward magnet unit (solenoid) are given (Table 1).

The vacuum and magnet systems assembly takes several steps because of ECS structural features. At the final stage of vacuum system assembly the vacuum chamber is baked up, bulk getters and cathode of electron gun are activated. On finishing the assembly and testing of the high voltage system, the e-beam is sent from the gun to the collector.

servsemenov@gmail.com

ISBN: 978-3-95450-197-7 doi:10.18429/JACoW-RUPAC2018-TUPSA22

Table 1: Parameters of Electron Cooling System

Parameter	Value
Electron Energy, keV	1,5 ÷ 60
Energy stability, ΔE/E	≤ 1·10-5
Collector potential, kV	0,5 ÷ 2,0
Electron beam current, A	0,2÷ 1,0
Beam current stability, ΔI/I	$\le 1\cdot10^{-4}$
Electron beam loss current, δI/I	$\le 3\cdot10^{-5}$
Maximum power in collector, W	2 000
Straight solenoid length, mm	2522
Full length with vacuum valves, mm	6355
Electron gun cathode diameter, cm	3,0
Longitudinal magnetic field, kG	1,0÷2,0
Uniformity in straight solenoid, ΔB/B	$<10^{-4}$
Vacuum near cathode, Torr	$<10^{-9}$
Vacuum in cooling section, Torr	$<10^{-10}$
Total power at magnetic field 2 kG, kW	500

ASSEMBLY AND INSTALLATION

The electron cooling system was sent to Dubna in March 2017 by Institute of Nuclear Physics (Novosibirsk), and arrived at JINR on the 4th of April 2017.

Before arrival, the site was prepared for installation; the floor under ECS was strengthened by placing additional stabilizing jacks to hold up 15 tons weight. Also, before arrival to JINR, calculating of heat-cold pass in parts, connected to booster magnets, began.

ECS has become the first of the booster elements, installed in the proper location. Before its shipping to JINR, the development of "heat-cold" transition for connecting beam chambers at different temperatures was begun. ECS works at room temperature and is connected with the chamber of superconducting magnets which work at cryogenic temperatures.

In April-May 2017 assembly of ECS without the vacuum system began, as well as connection of all systems for testing and functioning of ECS. Geodetic works were performed (adjustment) to place ECS relatively to booster beam. The adjustment was made using tracker LeicaAT4101. High-voltage system was hooked up, water-supply for ECS cooling was conducted.

Magnetic Fields Measurements, High-Voltage System Testing

ECS's full power at magnetic field of 2 kG is 500kW, and to provide such power supply an additional electric substation is being built specifically for ECS. While it has not been finished yet, the high-voltage system testing was performed using the temporary scheme, of only 120 kW, corresponding to 1 kG.

At present (as of October 2018) a new electrical rack with a capacity of 700 kW and a new cable system which will enable the Electron Cooling System operate at full power are being prepared for commissioning (Fig. 2).

Figure 2: Main electrical rack.

Magnitude measurements were made of compass method. Works in order:

- Mechanical installation of stands, optics, moving system, etc.;
- Final adjustment of cooler (laser tracker);
- Magnitude measurements;
- Placing of coils (circuits)

While adjusting the cooling section of booster ECS, mean-square magnetic field nonuniformity was achieved $B/Bs=2\cdot10^{-5}$i n a wide range of magnetic field values at proportional adjustment (tune) of magnetic fields.

Initial $rms(Bx)=8\cdot10^{-5}$, $rms(By)=3.5\cdot10^{-5}$.

Final $rms(Bx)=1.6\cdot10^{-5}$, $rms(By)=2.0\cdot10^{-5}$.

Disassembly of Magnetic System for Further Assembly with the Vacuum System

Performed works:

- Cut of water, power supply;
- Taking-out of toroidal rings and solenoids;
- Preparation of heaters and insulation, where possible in advance;
- Assembly of derivation plates and bent chambers;
- Assembly of vacuum system with further leak hunting;
- Assembly of magnetic system.

Bake Up

To achieve the required vacuum, bake up was performed within 3 days at T=250C, and by the end of August 2017, the value was

- Performed works:
- Installation of warm-up system;
- Warm-up;
- Degasification of TSP;
- NEG activation;
- Cathode activation;
- Pumps switching-on;
- UHV vacuum gages connection;
- Titanium pump activation.

In August 2017 the pressure $P= 2.5\ 10^{-9}$ Pa was achieved.

ISBN: 978-3-95450-197-7 doi:10.18429/JACoW-RUPAC2018-TUPSA22

FIRST EXPERIMENTS WITH ELECTRON BEAM

On December 2017, first experiments with electron beam were performed (Fig. 3). An electron energy was 1.74 kV, which corresponds to the injection energy of gold ions to the booster 3.2 GeV/u, the electron current was 150 mA.

The electron cooler system has the control system. An example of horizontal and vertical electron beam signals from 4 pick-up stations (gun, entry and exit of straight solenoid, collector) are shown on Fig. 4.

Next step of the cooler adjustment is the operation on the maximum energy 60 kV which is corresponds to the intermediate ion energy 100 MeV/u when the final beam parameters will formed before the acceleration to the final energy 600 MeV/u.

Finally, the electron cooling system will operate in the regime with both energies during one cycle. At the injection energy cooler will be used for the accumulation of the ion beam. Then the ion beam is accelerated to the intermediate energy where cooling method will be again applied.

Figure 3: Experiments with electron beam.

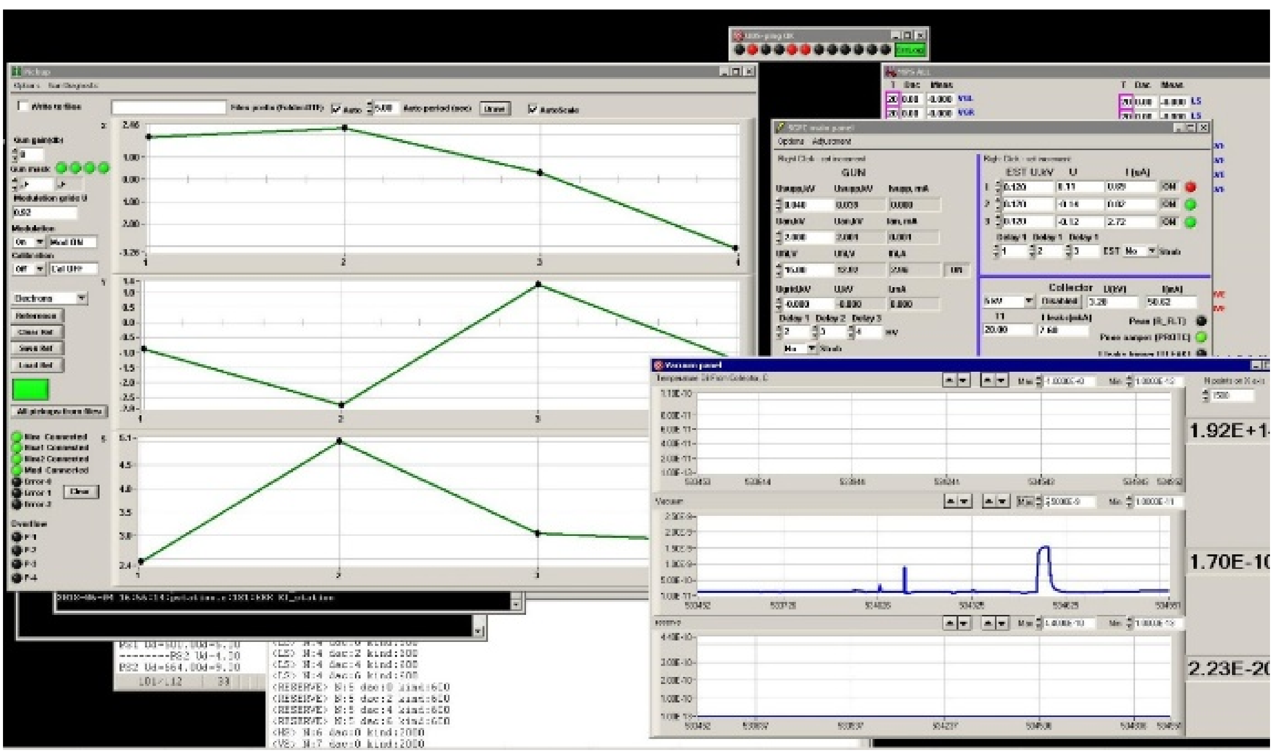

Figure 4: Screenshot of the control system of the electron cooler.

REFERENCES

[1] L.V.Zinovyev, A.V.Smirnov, A.S.Sergeev, S.V.Semenov, S.Y.Kolesnikov, E.A.Kulikov, Y.A.Tumanova, A.V.Alfeyev, M.I.Bryzgunov, A.V.Bubley, V.B.Reva. Start of Electron Cooling System for the NICA Booster. Physics of Particles and Nuclei Letters, 2018, Vol. 15, No. 7, pp. 735–738.

[2] M.Bryzgunov, A.Bubley, V.Panasyuk, V.Parkhomchuk, V.Polukhin, V.Reva, Low Energy Cooler for the NICA Booster. Proceedings of RUPAC2012, Saint|-|Petersburg, Russia, 2012, pp.391-393.