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PHYSICS AND TECHNIQUE OF ACCELERATORS

Construction of Stations for Applied Research at the NICA Accelerator Complex

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Abstract—The applied stations: ISCRA (energy range of 150–500 MeV/n), SOCHI (ion energy up to 3.2 MeV/n), and SIMBO (energy range 500–1000 MeV/n) are under construction as a part of the NICA accelerator complex. These stations will be used for single event effects testing of as capsulated, so decapsulated microchips, and for radiobiological research and modelling of influence of heavy charged particles on cognitive functions of animal's brain, respectively. This paper presents the applied stations description. Mounting and commissioning of the SOCHI station are completed. The ISCRA and SIMBO stations mounting is planned in early 2022. Beam runs at the SOCHI were performed in December 2021, at the ISCRA and SIMBO are planned in fall 2022.

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INTRODUCTION

Within the framework of the NICA (Nuclotron-based Ion Collider fAcility) project [1] at JINR, the ARIADNA (Applied Research Infrastructure for Advanced Developments at NICA fAcility) infrastructure for three applied research areas is being constructed.

The first area includes an applied research station for microchips for Single Event Effects (SEE) testing at the energy range of 150–500 MeV/n to predict, evaluate and control the radiation resistance of these products for their further use as part of onboard spacecraft and aviation systems. An Irradiation Setup for Components of Radioelectronic Apparature (ISCRA) is under construction for this purpose in the Measurement Hall [2] of Building 1 of the Laboratory of High Energy Physics. A long-range high-energy ions at the ISCRA applied station allows to irradiate the microchip in a Bragg peak regime, as well as avoid the decapsulation procedure of microchip before irradiation.

The second area includes an applied research station for testing of decapsulated microchips (ion energy of 3.2 MeV/n). For this purpose, a Station Of CHip Irradiation (SOCHI) is being constructed in Building 1 of the Laboratory of High Energy Physics [2].

The third area includes an applied research station for space radiobiological researches and modelling of influence of heavy charged particles on cognitive functions of the brain of small laboratory animals and primates (energy range 500–1000 MeV/n). The Setup for Investigation of Medical Biological Objects (SIMBO) is being constructed in the Measurement Hall of Building 1 of the Laboratory of High Energy Physics [2].

SOCHI APPLIED RESEARCH STATION

The SOCHI station (Fig. 1, Table 1) is designed to research and tests of promising semiconductor micro- and nanoelectronics products for determination of SEE sensitivity to low energy heavy charged particles produced at the exit from the HILAc.

Table 1 shows the sufficient ion beam parameters for the planned work.

The equipment for the SOCHI station is being developed by the JINR-NRC "Kurchatov Institute"

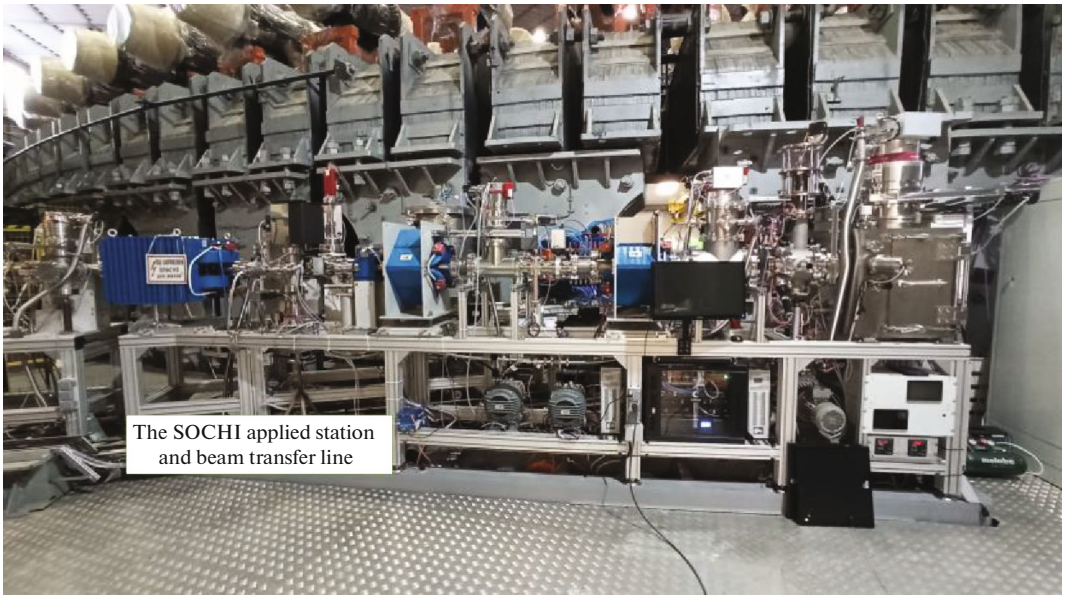

Fig. 1. SOCHI station and it's transfer line from HILAc.

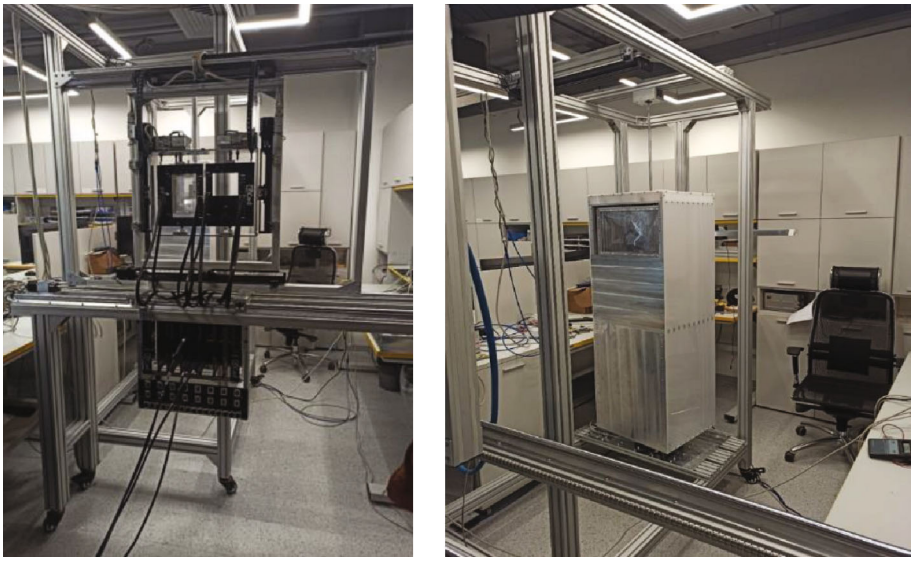

Fig. 2. The ISCRA positioning system (left) and energy degrader (right).

collaboration with participation of SPELS/MEPHI, GIRO-PROM, VST. The diagnostics system consists of the following detectors: microchannel plates, system for online diagnostics and control of peripheral ion flux density and fluence (four scintillation detectors based on multichannel photomultipliers), the fast total-absorption scintillation detector with optical readout, a Faraday cup, fast total absorption phosphor screen. The detector signals are integrated into the general data acquisition system [3]. The mounting of the SOCHI applied station was completed in October–November 2021. The first experiment with C^{4+} ion beams was done in December 2021. The ion beams were transported through the new beam transfer line to the applied station, where they were registered by the SOCHI detectors. The further SOCHI commissioning is planned in spring 2022.

ISCRA APPLIED RESEARCH STATION

The ISCRA station (Fig. 2, Table 2) is designed to research and tests of promising semiconductor micro- and nanoelectronics for determination of SEE sensitivity to high energy heavy charged particles. The equipment for the ISCRA station is being developed

Table 1. Technical requirements for the ion beams at the SOCHI station

Ion types	$^{12}C^{4+}$, $^{40}Ar^{8+}$, $^{131}Xe^{22+}$, $^{84}Kr^{14+}$, $^{169}Tm^{21+}$, $^{197}Au^{31+}$, $^{209}Bi^{35+}$
Ion energy at the exit from the HILAc, MeV/n	3.2
Ion flux density, particles/(cm^2 s)	10^3...10^5
Maximum irradiation area, mm	dia 29
Beam diameter, mm	dia 73

Table 2. Technical requirements for the ion beams at the ISCRA station

Ion types, energy MeV/n	$^{197}Au^{79+}$	150–350
	$^{131}Xe^{54+}$	150–367
	$^{12}C^{6+}$	150–392
Ion flux density, particles/(cm^2 s)	10^2...3×10^5	
Irradiation area in the scanning mode/nonscanning mode, mm	200 × 200/dia 29	
Flux uniformity for the maximum irradiation area in the scanning mode/nonscanning mode, %	15/10	

by the JINR-NRC "Kurchatov Institute" collaboration with participation of SPELS/MEPHI, GIRO-PROM.

The following detectors present the diagnostics system: ionization chamber, proportional wire ionization chamber, miniature gas-filled ionization chamber, a scintillation-fiber detector, a silicon detector, an online particle flux density detector based on four scintillators (or four silicon detectors). The absolute measurements of the ion flux density can be performed using 0.1-mm-thick plastic foils as offline detectors at specified points [3].

Table 3. Technical requirements for the ion beams at the SIMBO station

Ion types	$^{12}C^{6+}$, $^{40}Ar^{18+}$, $^{56}Fe^{26+}$, $^{84}Kr^{36+}$
Ion energy at the exit from the Nuclotron, MeV/n	500–1000
Ion flux density, particles/(cm^2 s)	10^3...10^6
Radiation dose, Gy	1–3
Irradiation area in the scanning mode/nonscanning mode, mm	100 × 100/dia 10

SIMBO APPLIED RESEARCH STATION

The SIMBO station (Fig. 3, Table 3) is designed for radiobiological researches to simulate the effects of heavy charged particles of galactic and solar cosmic rays on the cognitive functions of lower primates and small laboratory animals. The equipment for the SIMBO station is being developed by the JINR-VST collaboration with participation of Ostec.

The following detectors represent the diagnostics system: four ionization chambers, the thin scintillation counter, the diamond semiconductor detector, the system based on four scintillation detectors for online diagnostics and control of peripheral ion flux [3].

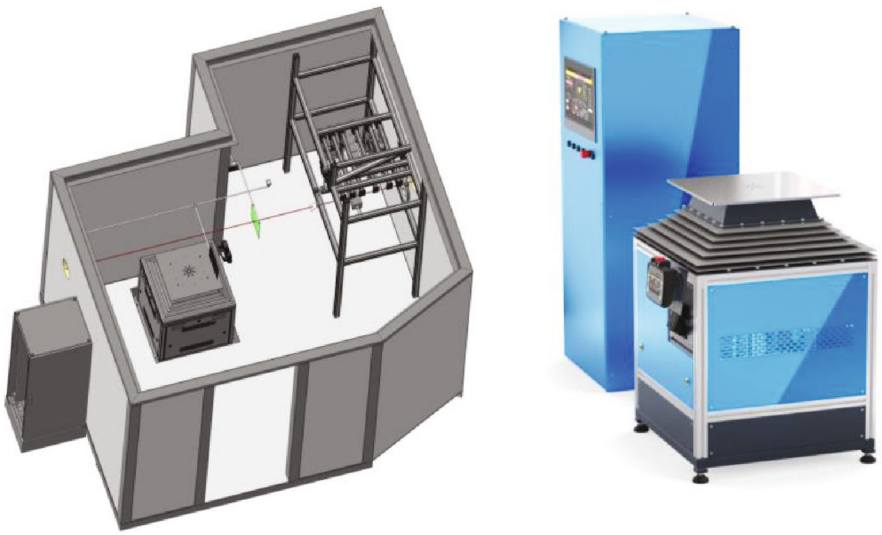

Fig. 3. General 3D view of the SIMBO station (left) and positioning device for irradiated objects (right).

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CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

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