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MAGNETIC MEASUREMENTS OF THE MULTIPOLE CORRECTORS OF THE NICA BOOSTER

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Abstract

The lattice of the NICA Booster includes eight superconducting multipole correctors for compensation of the main field errors of dipole and quadrupole magnets. The corrector includes four coils: quadrupole, two sextupoles and octupole. The magnetic field mapping at "warm" carry out by Hall sensor. High precision movement system for Hall sensor inside the magnet was developed and produced. The paper describes the design of the dedicated system, the results of the fist magnetic measurement and its comparison with calculations.

INTRODUCTION

NICA (Nuclotron-based Ion Collider fAcility) is the new accelerator complex being under design and construction at JINR since 2007 [1]. The accelerator complex includes two injector chains, a superconducting booster synchrotron Nuclotron and a collider consisting of two storage rings. The main goals of the Booster are the following: accumulation of $4 \cdot 10^9$ Au^{32+} ions; acceleration of the heavy ions up to energy required for effective stripping; forming of the required beam emittance with electron cooling system. According to specification [2], the lattice of the NICA Booster (see Fig. 1) includes eight superconducting multipole correctors for compensation of the main field errors of dipole and quadrupole magnets. The corrector includes four coils: quadrupole, normal and skew sextupole and octupole. Magnets produced at the Veksler and Baldin Laboratory of High Energy Physics (VBLHEP) at JINR.

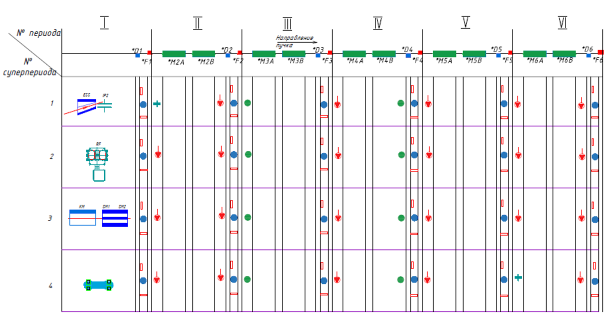

Figure 1: Green circles indicate multipole correctors.

MAGNET CIRCUIT DESIGN

Figure 2 shows the magnet front view. Magnet pole tip radius is 95 mm, outer diameter is 237 mm and leght 360 mm. Diameter of conductor with isolation 0.56 mm.

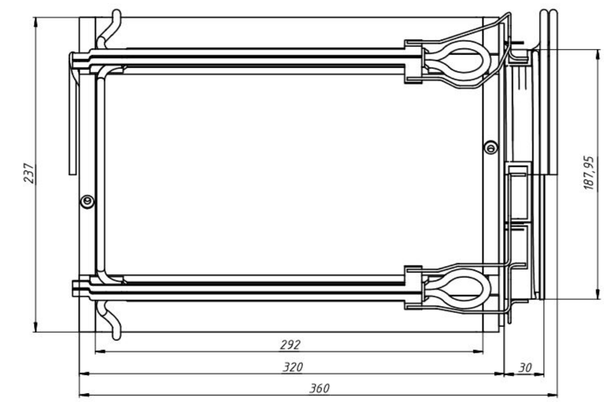

Figure 2: Main view of the multipole magnet.

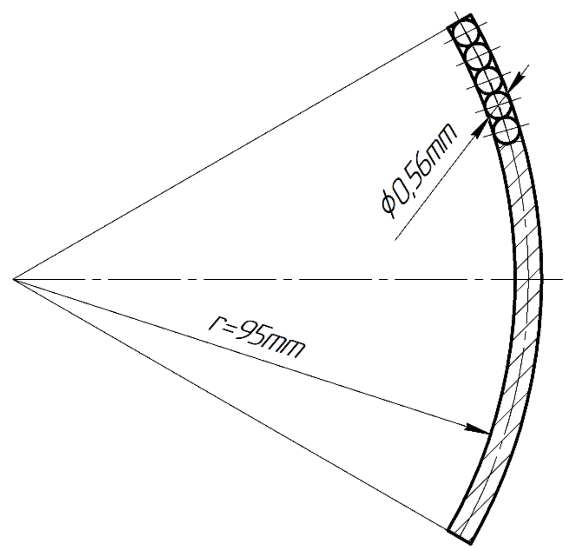

Figure 3: Coil cross-section.

The coils (Fig. 3) were exited using the same operating current. The different configurations of the coils that are related to different magnetic components of the magnet is shown in Fig. 4.

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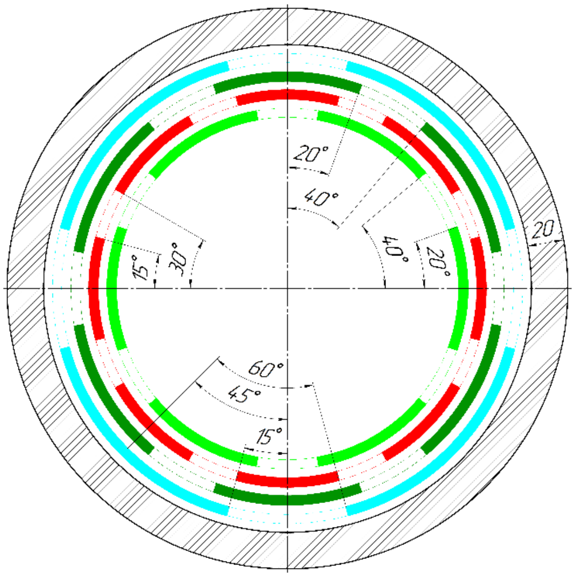

Figure 4: Configuration of coils: normal-type: red – sextupole, light green – octupole; skew-type: dark green – sextupole; blue – quadrupole.

THE CALCULATION OF PARAMETERS OF THE CORRECTION MAGNETS

The calculations of parameters of multipole correctors was carried out for the central cross-section using software for simulation of electromagnetic processes by the finite element method Cobham Opera-2d Tosca (see Fig. 5). Relative magnetic permeability of yoke material: $\mu/\mu_0 = 3000$, coil number of turns for quadrupole – 89, sextupole – 58 normal and 57 skew, octupole – 42. The current is distributed evenly over the coil area.

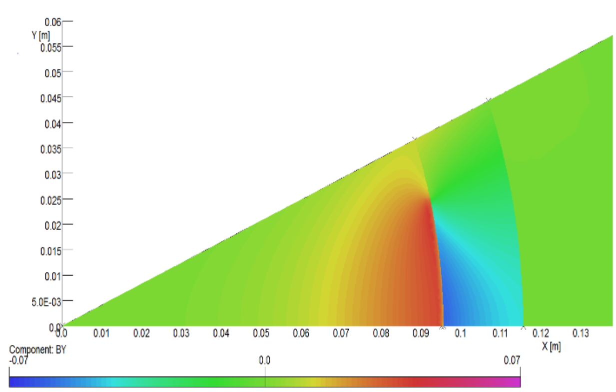

Figure 5: Simulation of multipole correctors.

In Table 1 are given results of modeling correctors in Cobham Opera-2d Tosca software for the coil installed in the iron yoke. Values are given on the radius R_{ref}= 75.6 mm.

Table 1: Results of Modelling the Corrector Parameters

Type	α, [°]	I, [A* *turns]	Results Opera-2d, B*10^{-4}, [T]
Quadrupole	30	178	22.707
Sextupole	20	114	23.297
Octupole	15	84	16.765

SYSTEM FOR HALL PROBE MOVEMENT

An original stand was created to measure magnetic field map of a multipole corrector. It consists of two linear motorized linear stages, motorized rotation stage, Keysight 8.5 Digital Multimeter, Hall probe HGT-1020 (see Table 2), one power supplies for magnet and Hall probe (see Fig. 6).

Table 2: Transverse Hall Probe Specifications

Transverse	HGT-1020
Active area	0.76 mm in diameter
Input resistance	2 Om
Nominal control current	100 mA
Magnetic sensitivity	8.64 mV/kG
Maximum linearity error	±1% rdg
Mean temperature coefficient of magnetic sensitivity	-0.08%/ºC
Mean temperature coefficient of resistance	+0.18%/ºC

Hall probe is located at the end of the rod. The rod is rigidly fixed to the rotation stage. Rotation stage provides 360º degree sensor rotation, with an accuracy 0.6 arcsec. Two linear motorized linear stages allow the sensor to move in the transverse plane with accuracy 5 μm.

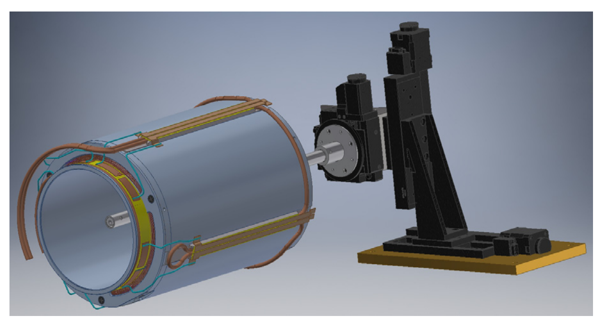

Figure 6: Layout of the magnetic measurement system.

FIELD MEASUREMENT RESULTS

Hall probe was used to measure the magnetic field. The calculations and first measurements field are carried out of the central magnet at the ambient temperature. Each coil was excited with a current of two amperes.

Figures 7,8 and 9 show the calculated and measured magnetic field component B_y for the different types of the coils.

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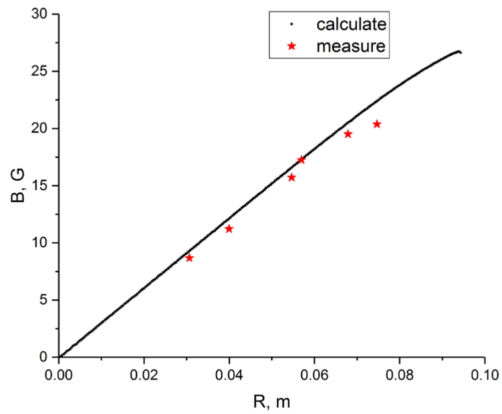

Figure 7: Skew quadrupole coil.

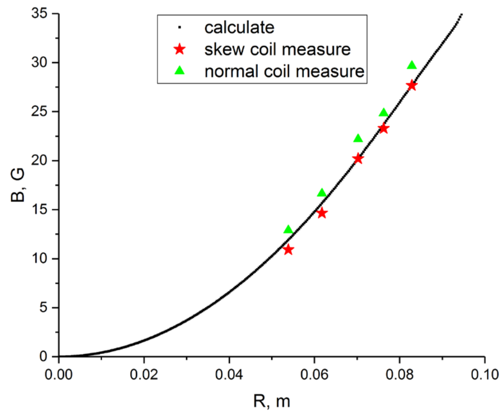

Figure 8: Sextupole coils.

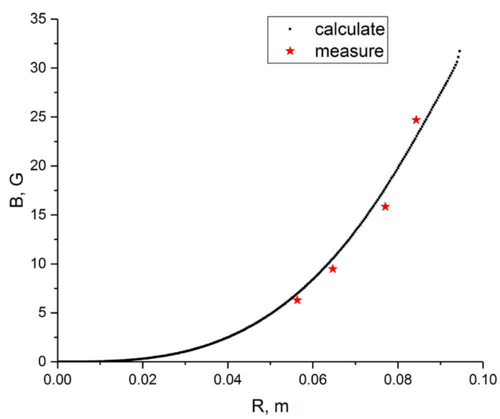

Figure 9: Octupole coil.

CONCLUSION

Magnetometric system based on the Hall probe for the measurement of multipole correctors has been designed and assembled. The first warm magnetic measurements of the serial multipole correctors were performed. Good correlation between the calculated data and the measurement results are shown. In the future, we plan to create a new displacement system for magnetic measurements. at the cryogenic temperatures with operating current of 100 A.

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