MAGNETS FOR THE COMBAS LARGE-ACCEPTANCE SPECTROMETER

S.M.ANANIEV, V.S.KASHIKHIN, E.A.LAMZIN, Yu.A.MYASNIKOV,
M.G.NAGAENKO, S.P.POTEKHIN, B.V.ROZHDESTVENSKY,
Yu.P.SEVERGIN, S.E.SYTCHEVSKY, N.F.SHILKIN
D.V.Efremov Scientific Research Institute of Electrophysical Apparatus (NIIEFA)
189631,St.-Petersburg,Russia

A.G.ARTYUKH
Joint Institute for Nuclear Research (JINR)
141980,Dubna,Russia

Abstract

The COMBAS large-acceptance high resolution spectrometer is under construction for experiments with heavy-ions accelerated by the tandem of U-400 and U-400M cyclotrons at the Laboratory of Nuclear Reactions, JINR, Dubna. Design aspects of the COMBAS magnets and results of 2D and 3D field simulation curried out to provide the necessary field distribution are given in the paper.

1. Introduction

The design of the COMBAS spectrometer magnet system has been completed and at present it is under production. The COMBAS [1] is a high-resolution large-acceptance analyzer, which is characterized by following parameters:
angle acceptance is 6.4 mster, maximum $\Delta p/p$ acceptance is about 10%,magnetic rigidity of ions $B\rho$ - 4.5 T-m,resolving power is 4300, channel length - 14.2m.
The magnet system is of a mirror symmetry with respect to the middle point. Each part of the channel consists of two main bending magnets (M1 and M2) with considerable radial variation of the field (Figures 1 and 2) and two correctors (M3 and M4) (Figures 3 and 4) [2].

To achieve the required parameters of the channel the second-order and third-order aberrations should be compensated [2]. The required values for the correcting sextupole and octupole components of the magnetic field are provided by special pole pieces profiling for all of the magnets and entrance and exit pole ends shaping for the magnets M3 and M4.

Each magnet is supplied by windings of the field correction system in order to increase the flexibility and reliability of the magnetic system.

2. Magnetic field analysis results.

Thorough numerical simulations were carried out to solve the problems of providing a rather complicated transverse field distribution and to analyze the fringe field in the end region of the magnets. A tolerance for field deviation from the specified distribution is equal to $\pm 2\cdot 10^{-3}$. The same tolerance is imposed on the longitudinal distribution of the field

$$\eta(x)=\int B(x,s)ds/(L_{eff}\cdot B(x,o))-1\,,$$

for the whole beam region. Here x is radial displacement, s is measured along the beam axis, $L_{eff}(x)$ is the desired value of the effective length for the specified x.

Calculation of pole pieces profiles described in Ref.2 was performed on the basis of a 2D model. The advanced field calculation was based on a 3D finite-element model (the mesh for each magnet included about 20 000 elements), the KOMPOT program package being used [3]. Some results for each magnet are presented in corresponding figures. The data on field calculations are given for the central part of the magnets, Two curves corresponding to 2D and 3D models. The use of the 3D model has made it possible:
i) to control the shape of pole pieces profile by two independent codes;
ii) to make the pole shape correction in the end region of the magnets according to the results of 3D calculations.

The last is especially important for the magnets M3 and M4 due to their small length.

3. Peculiarities of magnet production.

A tolerance on the processing accuracy for the pole pieces required to provide the necessary field distribution is about 0.05mm. While manufacturing the magnets a special stage is provided so that to additionally process the pieces shape at the end region according to the results of magnetic measurements. That will make it possible to take into account errors resulting both from some spread in magnetic properties of steel and magnets manufacturing and assembly. A tolerance for the accuracy of surface processing on the pole ends is ±0.1mm.

4. Conclusion.

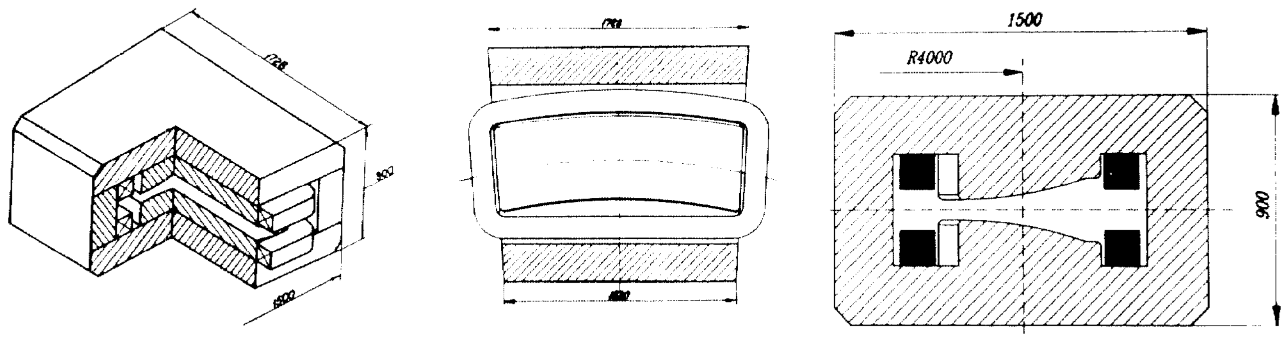
The analysis of the spatial field of the developed COMBAS spectrometer magnet system has shown this system to be able to provide the required magnetic field distribution.

5. References.

[1] M.G.Nagaenko, Yu.P.Severgin, V.A.Titov and A.G.Artyukh, "Beam optics of large acceptance magnetic channel for separation of radioactive nuclei",.in Proc. of the 2nd European Particle Accel. Conference, vol.2, pp.1312-1314, 1990.

[2] "Magneto-Optic System of a Large-Acceptance Channel for Radioactive Nuclei Separation". Kashikhin V.S. et.al. presented at MT12 conference, Leningrad, USSR, 24-28 June 1991.

[3] N.I.Doinikov, E.A.Lamzin, A.S.Simakov, S.E.Sytchevsky,"Program Package KOMPOT for 3D Simulation of Static Magnetic Fields of Electromagnetic Systems". Preprint NIIEFA Б-0741. Moscow: CNIIAI, 1986



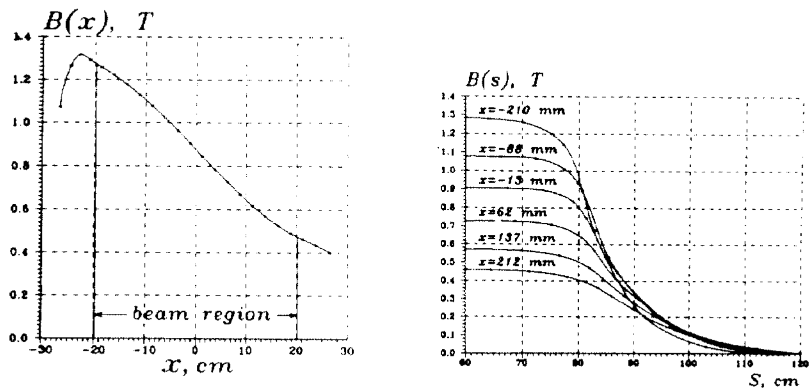
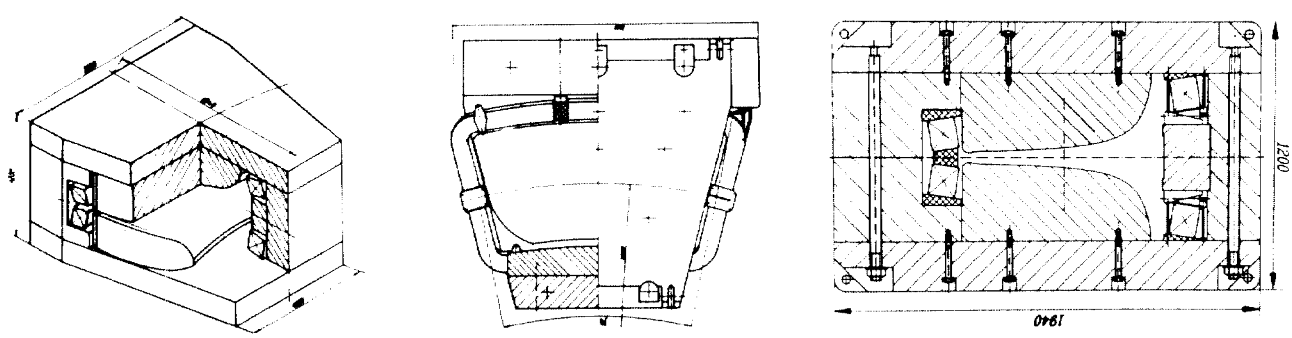


Figure 1
M1 magnet cross sections, magnetic field distributions in the central cross section and over the longitudinal axis for a set of radial displacements.



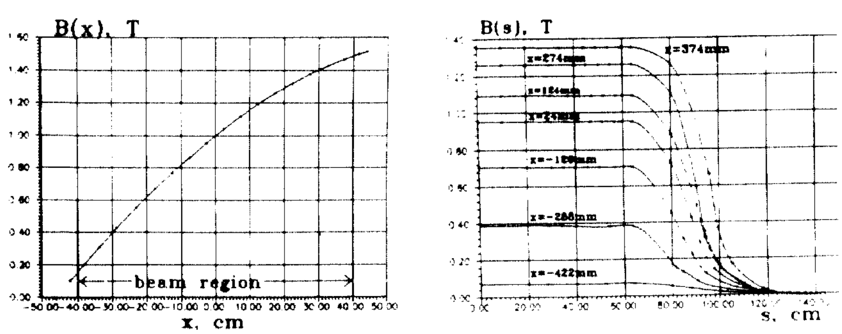
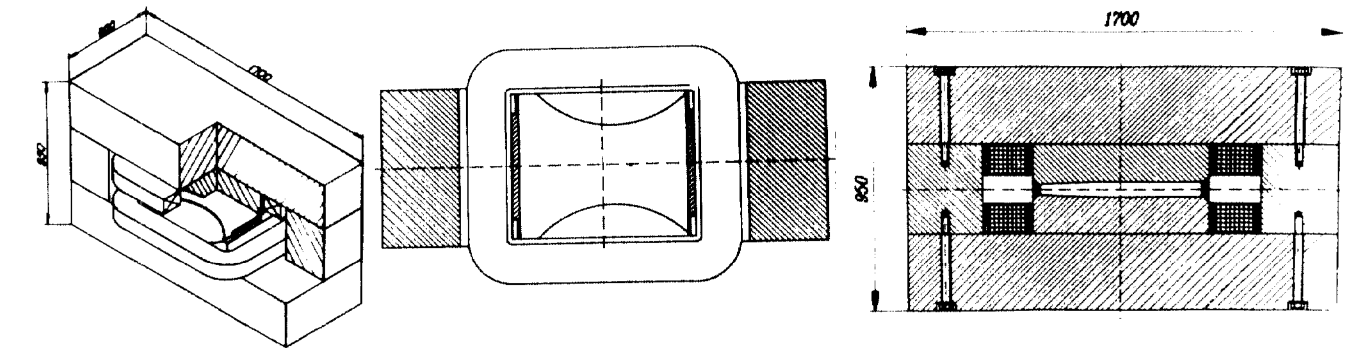


Figure 2
M2 magnet cross sections, magnetic field distributions in the central cross section and over the longitudinal axis for a set of radial displacements.



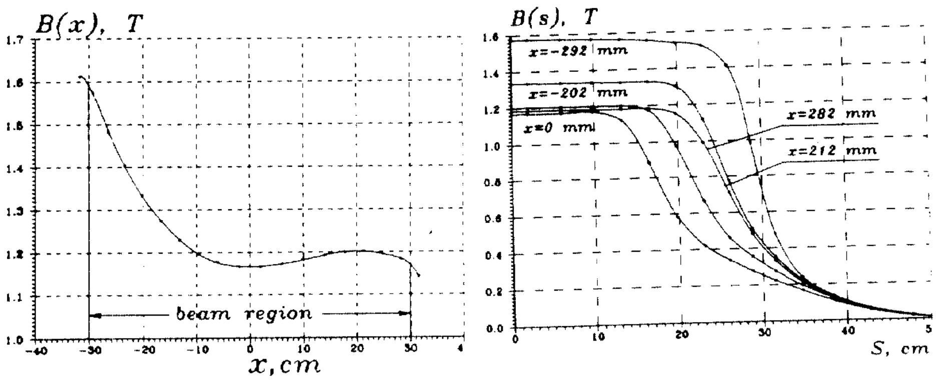
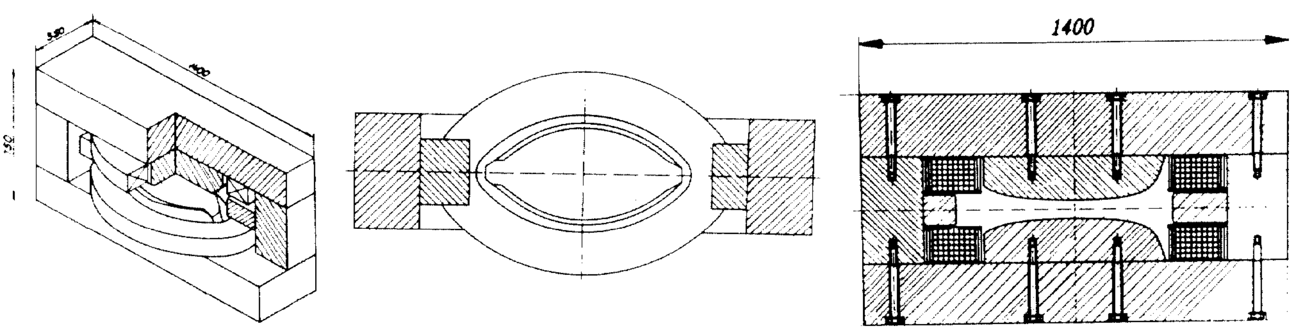


Figure 3
M3 magnet cross sections, magnetic field distributions in the central cross section and over the longitudinal axis for a set of radial displacements.



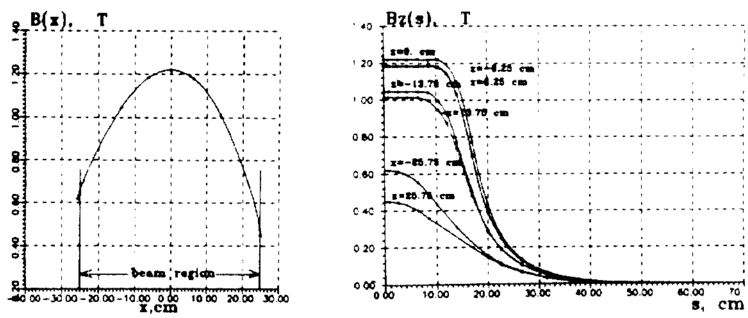


Figure 4
M4 magnet cross sections, magnetic field distributions in the central cross section and over the longitudinal axis for a set of radial displacements.