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LENS WITHOUT POLES: CONCEPTUAL DESIGN AND POSSIBILITIES OF USE IN THE CHANNEL OF SCANNING OF CYCLOTRON BEAMS

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It is shown that the use of a wide aperture magnetic lens without poles gives additional possibilities for improvement of efficiency of scanning systems of cyclotron beams: increase in an angle of deflection and, as effect, reduction of length of the channel; possibility of improvement of homogeneity of irradiation due to profiling magnetic conductors; possibility of alignment of fall angles of ions at edges of a target.

Показано, что использование широкоапертурной бесполюсной магнитной линзы дает следующие дополнительные возможности для увеличения эффективности систем сканирования циклотронных пучков: увеличение угла отклонения и, как следствие, уменьшение длины канала; возможность улучшения однородности облучения за счет профилирования магнитопроводов; возможность выравнивания углов влета ионов на краях мишени.

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INTRODUCTION

For irradiation of targets with big sizes or moving films by ion beams extracted from cyclotron electric or magnetic scanners are usually used [1, 2]. To get a maximum bending pulse both systems have their own restrictions. In case of an electric deflector, the probability of electric breakdown increases. In case of a magnetic scanner, high reactive and active powers are needed and, as effect, problems with cooling arise. Hitherto general decision of these problems is a long drift space. For instance, at irradiation of 600 mm width films by the DC-60 beam the drift length about 8 m is required [2].

CONCEPTUAL DESIGN

For increase of efficiency (angle of deflection) of scanning systems we offer to use a magnetic lens without poles (MLWP) with static field of quadrupole structure, located between the scanner and the target (Fig. 1).

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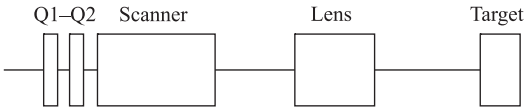

Fig. 1. Typical layout of beam line with additional lens. Q1–Q2 is a standard quadrupole doublet

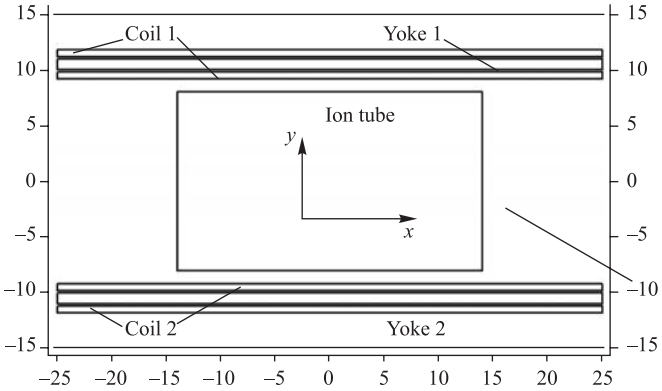

Fig. 2. Schematic view of MLWP cross section

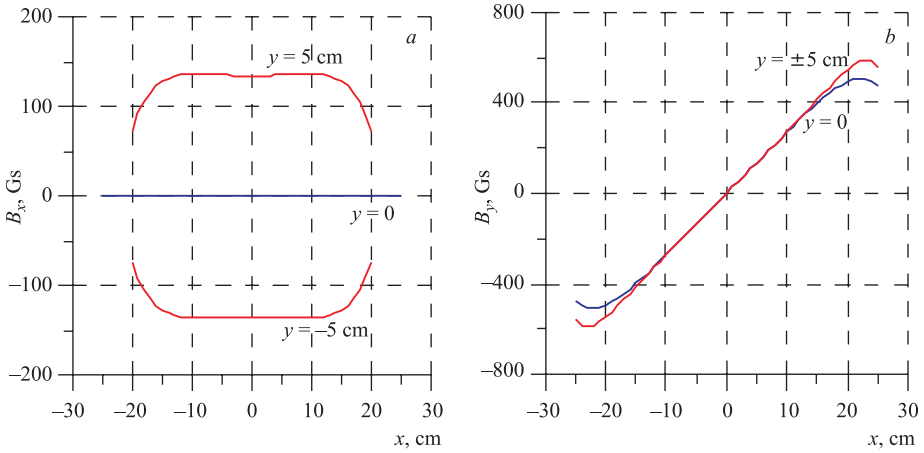

Fig. 3. Distributions of horizontal (a) and vertical (b) components of magnetic field

Distance between lens and scanner must be enough long, that maximum deflection of beam from axis significantly exceeds the beam sizes in this direction. As effect, aperture of lens must be enough wide, particularly in horizontal plane (plane of scan). One of the possible decisions for creation of such a lens can be portioned coils on separate magnetic conductors (yokes), disposed enough far off each other.

Schematic design of such a lens is shown in Fig. 2. Distributions of transverse components of magnetic field are shown in Fig. 3. Calculations were fulfilled by means of program POISSON [3].

POSSIBILITIES OF USE

Using of traditional scanning systems for big angles of deflection except technical difficulties has defect, connected with significant deterioration of homogeneity of irradiation. Proposed design of lens allows one to compensate easy this defect due to suitable form of yokes. Such a way is possible to compensate nonlinearity of pulse of current in system of scan.

The lens without poles gives principle possibility to justify fall angles of ions at edges of a target. This is possible to realize by means of similar lens located before target directly. Certainly power of such a lens (heat losses, source power) is enough significant, so the lens aperture in the region of target is maximum.

To reduce power of feeding (and, accordingly, heat losses) of lens is possible, reducing transverse size of its coils (aproximately before horizontal sizes of camera) and using of shimming, for instance, as shown in Fig. 4. The influence of shimming on the magnetic field distribution is illustrated in Figs. 5 and 6.

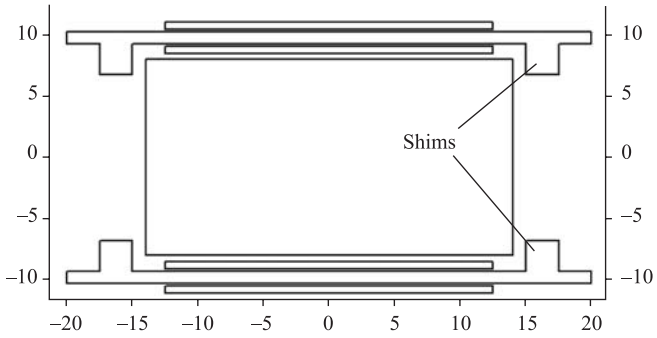

Fig. 4. Schematic view of MLWP with shims

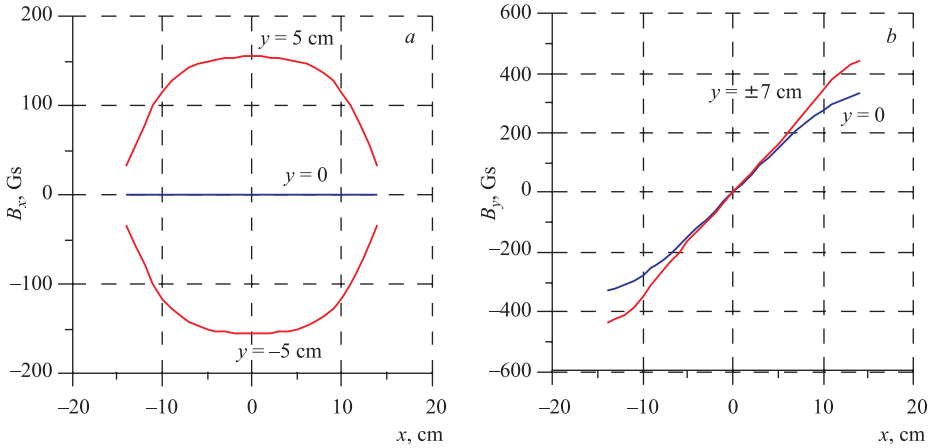

Fig. 5. Distributions of horizontal (a) and vertical (b) components of magnetic field with shortcut windings without shimming

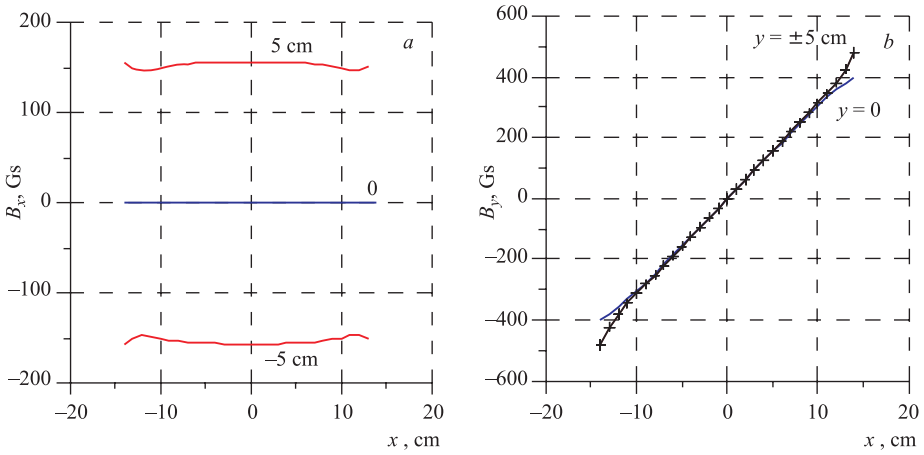

Fig. 6. Distributions of horizontal (a) and vertical (b) components of magnetic field with shortcut windings and shimming

CONCLUSION

Preliminary calculations show that using of a wide aperture magnetic lens without poles gives additional possibilities for improvement of efficiency of scanning systems:

— increase in an angle of deflection and, as effect, reduction of length of the channel;

— possibility of improvement of homogeneity of irradiation due to profiling magnetic conductors;

— possibility of alignment of fall angles of ions at edges of a target.

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