FIELD DISTRIBUTION OF THE 90° BENDING MAGNET OF THE IFUSP MICROTRON*

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Abstract

The IFUSP Microtron transport line guides the 5 MeV electron beam from the booster to the main microtron, where it can be accelerated up to 38 MeV in steps of 0.9 MeV. A few meters after leaving the main microtron, the beam is guided to the experimental hall, which is located 2.7 m below the accelerator room. The level translation is made by two 90° bending magnets. In the experimental hall there is a switching magnet to drive the beam to two different experimental lines. Each of these lines has another 90° bending magnet. These magnets were designed, constructed and characterized in house. In this work we present the analysis of the field distribution of these 90° bending magnets. We also present a reproducibility analysis where the field distributions of two twin magnets are presented.

INTRODUCTION

The Laboratório do Acelerador Linear of the Instituto de Física da Universidade de São Paulo (LAL-IFUSP) is building a cw race-track microtron, with electron beam energies ranging from 5 to 38 MeV, in steps of 0.9 MeV. The accelerator consists of a linac injector that delivers a 1.8 MeV beam to a small microtron (booster) that accelerates the electrons to 5 MeV. In the exit of this stage, the beam is guided to the main microtron for final acceleration. There is a transport line to guide the beam to the experimental hall, which is located 2.7-m below the accelerator room. This level translation from the uper to the lower floor is made by two twin 90° bending magnets and the beam is guided to a switching magnet that may drive the beam to one of two different experimental lines. Each of these lines has another 90° bending magnet. Figure 1 presents a scheme of the accelerator, with the 90° bending magnets signaled by arrows.

These are sector type magnets and were constructed in the LAL-IFUSP. In this work we present the field distribution comparison of the magnets used for beam leveling in the experimental room. A picture of one of the 90° bending magnets is presented in Fig. 2.

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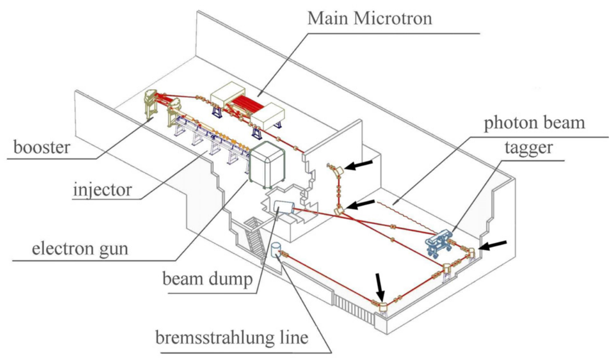

Figure 1: Lay-out of the accelerator and the positions of the 90 bending magnets.

Figure 2: Photo of one of the 90° bending magnets.

METHODOLOGY

The magnets under investigation were characterized by mapping the normal field at the mid-plane with a Hall probe and a computerized positioning system [1]. A digital gaussmeter with a relative precision of 0.2%+0.01G on the selected mode [2] was used and the mapping was made in steps of 4.41 mm in both directions. For comparison purposes the mappings of both magnets were normalized and superposed using an algorithm that minimizes the squared mean differences between both mappings in the MatLab [3] platform. During the process of superposition interpolation of the field values in positions located between adjacent measurements was necessary, since the mapping steps (4.41 mm) limit an exact superposition.

RESULTS

Figures 3 and 4 present the mid-plane mapping of two dipoles. It is possible to observe a small difference in the mapping area. The comparison uses only the points contained in both mappings, therefore small differences in the mapping area could be ignored.

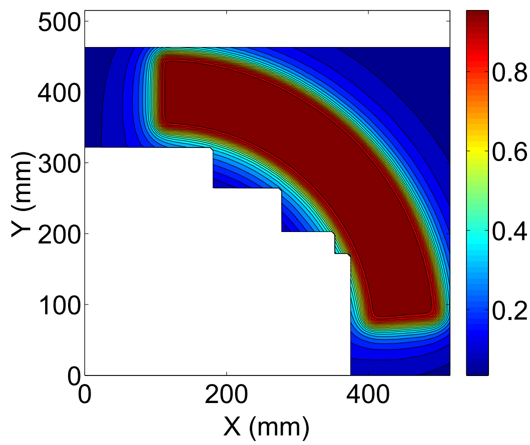

Figure 3: Normalized field distribution of the dipole #1.

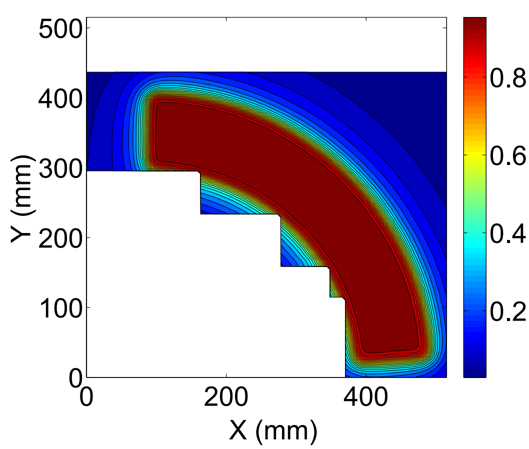

Figure 4: Normalized field distribution of the dipole #2.

Figure 5 presents the difference of the mappings in a bidimensional graph. It is possible to observe that field differences between both magnets are meaningful in the fringe field region.

Figure 6 shows the same from a different point of view. It is possible to verify that the differences stay within an interval of -5 to 4%. In the region of interest, that includes the uniform field region and the fringe fields in the regions

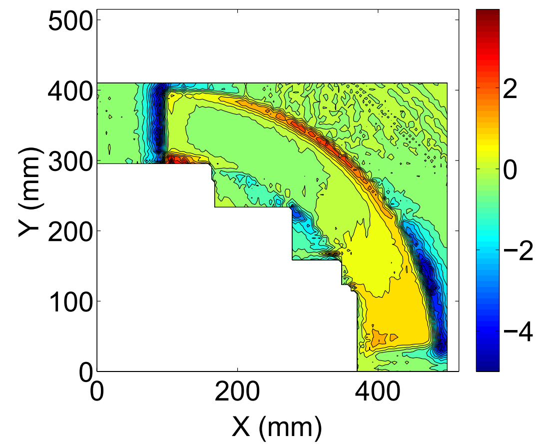

Figure 5: Field distribution differences between dipoles #1 and #2. Color scale in percent.

where the beam enters and leaves the magnet, the difference stays within the interval 0 to 5%.

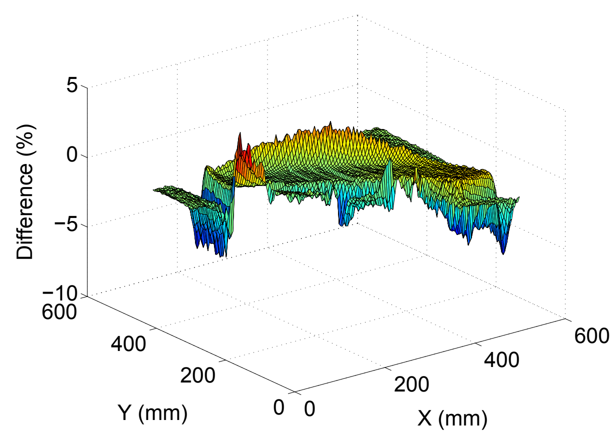

Figure 6: Tri-dimensional graph of field distribution differences between dipoles #1 and #2.

Plots of the fringe fields in the entrance and exit of the dipoles are presented in figure 7, which also shows the difference between their profiles.

CONCLUSIONS

This work presents the field distribution of two 90° bending magnets constructed at the LAL-IFUSP. These two bending magnets will be used for beam leveling to the experimental room, which is located 2.7 m below the accelerator room.

A comparative analysis of the field distributions was made and some differences were found in the fringe fields. At the entrance of the bending magnets the difference goes up to 5%, with the fringe field of magnet #2 higher than of magnet #1. At the exit, the difference goes up to 2%, with the fringe field of magnet #1 higher than that of magnet #2.

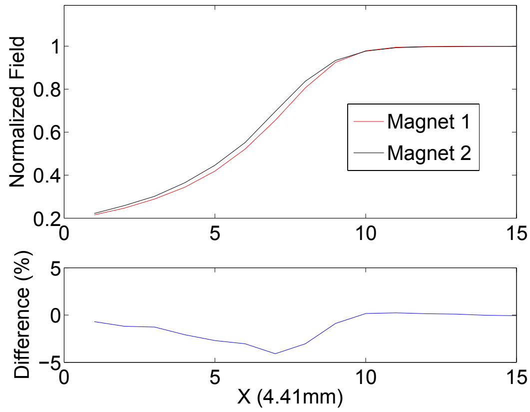

Figure 7: Fringe fields at the entrance of dipoles #1 and #2 and its differences.

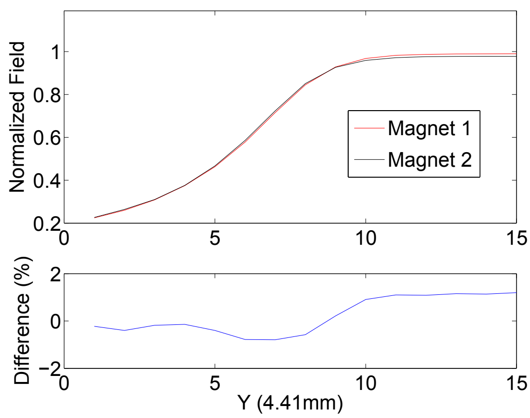

Figure 8: Fringe fields at the exit of dipoles #1 and #2 and its differences.

These differences can be compensated by reducing the magnet field of one of the magnets in order to reduce its effective length, but a part of these differences can be attributed to misalignment of the magnet with respect to the instrumentation.

A better alignment between the magnet and the instrumentation was not possible in this experiment, but the magnet support in the transport line is more precise (of the order of 10-2 mm) than the one used during the mapping (of the order of 10-1 mm).

REFERENCES

[1] LOPES, M. L., Dipolos Magnéticos da Linha de Transporte do Feixe do Microtron, M. Sc. Dissertation, IFUSP, São Paulo, 2002.

[2] Digital gaussmeter, F.W. Bell model 6010

[3] MatLab - The Mathoworks Inc.