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CTF3 Note 059

Measurement and Calibration of the Corrector Magnets and the Chicane Dipole Magnets for CTF3

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Abstract

The magnetic field of the CTF3 corrector and Chicane magnets was measured with a 3D hall probe setup. The resulting field plot was used to calculate the bending angle of the magnets with respect to the magnet current. This information will be used as a calibration for their use in the CTF3 injector.

AB/DIV Reps

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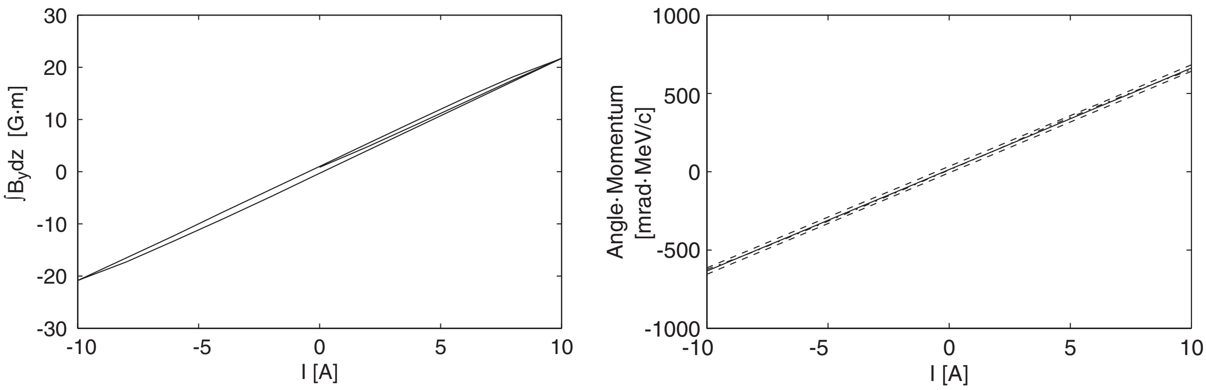

Figure 1: *Properties of the corrector magnet. The left–hand diagram shows the integrated field at a given current. The current was first increased from 0 to 10 A then decreased to -10 A and afterwards again increased to 10 A. This produces the hysteresis curve shown in the plot. The right–hand figure shows the product of angle and momentum at a given current. The upper and the lower dashed lines show the uncertainty limit due to the hysteresis of the corrector magnet.*

1 Introduction

The magnetic field of the CTF3 corrector and Chicane magnets was measured with a 3D hall probe setup where only one component of the field was taken into account. The resulting field plot was used to calibrate the magnets for their application in the CTF3 injector. Especially the first Chicane magnet is also used as a spectrometer magnet and therefore a decent calibration of the bending field is desired.

2 Corrector Magnet

The corrector magnet is used to correct the beam axis and therefore the bending angles are small (up to a few ten mrad). Thus the following assumption can be used for the calculation of the bending angle:

$$\sin(\alpha) \sim \alpha \qquad . \tag{1}$$

The field was measured with a magnet current in the range of -10 to 10 A. The current was first increased then decreased and finally increased again to measure the hysteresis due to the iron yoke of the corrector magnet. The resulting hysteresis curve is shown in the left part of Fig.1. The calculated bending angle with respect to the magnet current is shown in the right part of Fig.1.

A linear fit of the bending angle with respect to the magnet current leads to the following calibration coefficient of the corrector magnet:

$$\alpha \cdot p = 65.4 \cdot I\,[\mathrm{A}] \pm 19.6 \quad [\mathrm{mrad} \cdot \mathrm{MeV/c}] \qquad . \tag{2}$$

The uncertainty given in the previous equation results from the difference of the paths in the hysteresis curve. The difference between the upper and the lower path in the center of the hysteresis curve shown in Fig.1 is 1.37 G·m (difference of the maximum field: 7 G).

3 Chicane Dipole Magnet

The first Chicane dipole magnet will be used as a 30° spectrometer magnet. To take into account the variation of the magnetic field along the transverse axis of the magnet no longer the integrated field was used to calculate the bend of the magnet. Instead the differential equation of the magnetic force onto a charged particle was solved numerically using a Runge–Kutta solver of MATLAB ([1], [2]).

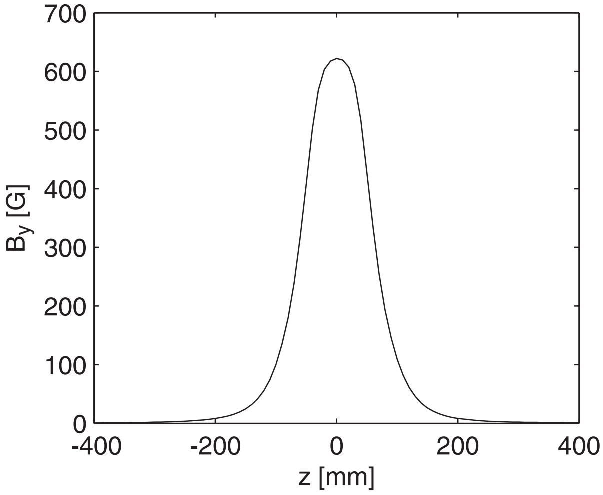

Figure 2: *Field plot of the Chicane dipole magnet along the beam axis. The applied current during the measurement was 50 A.*

The calculation was performed with an electron having a momentum of 17.853 MeV/c. This results in a necessary magnet current of 136.47 A for a bend of 30°. This leads to the following expression for the required magnet current:

$$\frac{I}{p} = 7.644 \quad \left[\frac{\mathrm{A}}{\mathrm{MeV/c}}\right] \qquad . \tag{3}$$

Due to the lack of cooling water, the measurements were performed at 50 A.

As a comparison by integration of the field on the central axis one finds the following results:

$$\mathrm{B_o} = 14.74 \quad [\mathrm{G} \cdot \mathrm{A}^{-1}] \tag{4}$$

$$\mathrm{l_{eff}} = 14.86 \quad [\mathrm{cm}] \qquad . \tag{5}$$

The two values are defined in the following way:

$$\mathrm{B_o} = \mathrm{B_{y,max}} \tag{6}$$

$$\mathrm{l_{eff}} \cdot \mathrm{B_o} = \int \mathrm{B}_y dz \qquad . \tag{7}$$

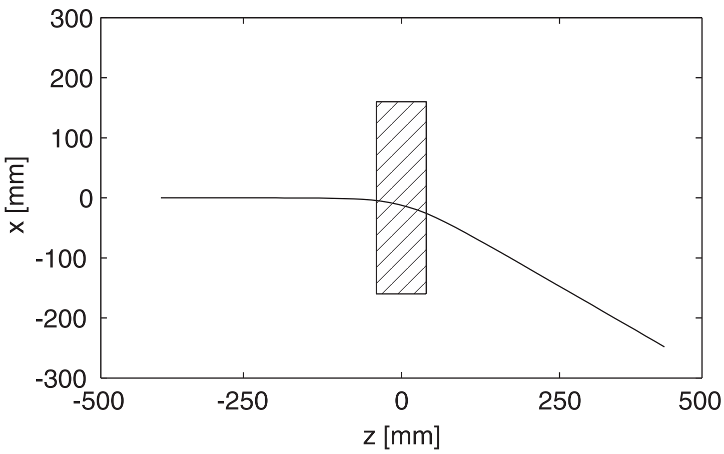

Figure 3: *Calculated path of an electron to the 30° spectrometer line (MATLAB output).*

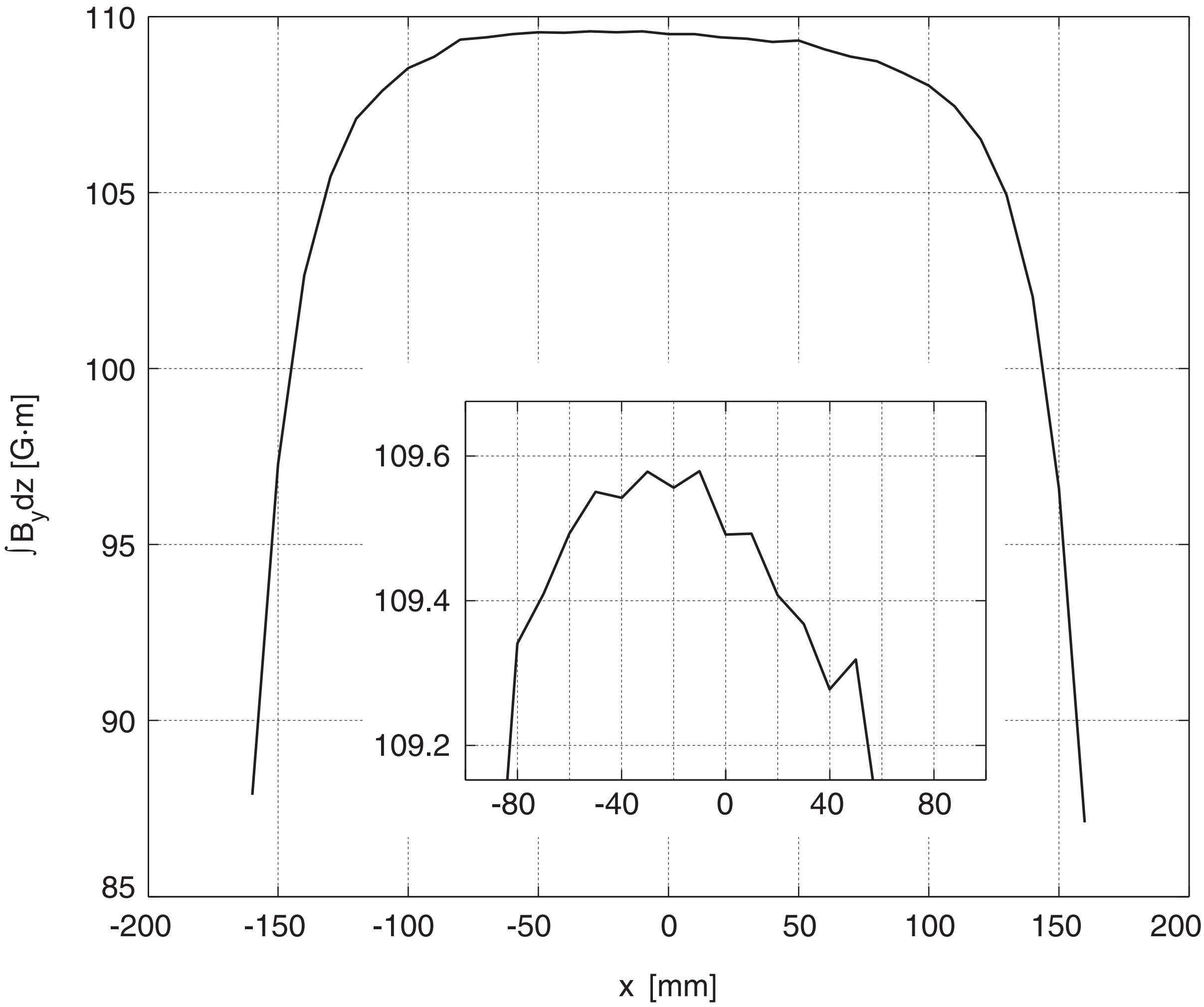

Figure 4: *The integrated field along the beam–axis over the width of the dipole magnet. In the small diagram the 'good–field–region' is magnified. The applied current during the measurement was 50 A. The U–shaped iron yoke is open in the positive direction of x.*

The required current for an 17.853 MeV electron and a bend of 30° calculated using B_o and l_{eff} would be 135.97 A. The discrepancy to the former result can be explained by the slope of the integrated field around the central axis as shown in Fig.4.

References

[1] MATLAB Online–Help

[2] Shampine L. F., Reichelt M. W., *The MATLAB ODE Suite*, SIAM Journal on Scientific Computing, Vol. 18, 1997, pp. 1-22