DAΦNE TECHNICAL NOTE

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MAGNETIC MEASUREMENTS ON THE FOUR SPLITTERS OF THE DAΦNE INTERACTION REGIONS

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1. Introduction

The measurements performed on the splitter prototype are described in [1]. Here we present the results of the checks performed on all the magnets in order to verify the homogeneity of the series production. The three splitters following the prototype have been delivered to LNF on February 24, 1997. The measurements have been performed in May.

Due to the relatively small deflection angle (9°), the independent power supplies on each magnet and each gap and the presence of one "Lambertson" corrector [2] before and one "C" corrector [3] after each magnet gap, it was decided to perform only few check measurements instead of all the maps performed on the prototype [1], without rotating the magnet. The splitters have therefore been measured only in the "reverse" mode [1], namely on the side with three alignment spheres. During all measurements, the two coils were powered in series with a single power supply.

2. Excitation curves

The first check performed on the magnets has been the verification of the field value at the magnet center after opening and closing again the two halves of the magnet. This check was not performed during the measurements on the prototype [1], and has therefore been carried out on the first measured magnet (Serial#3). Figure 1 shows the difference between the field values measured at the center of the right and left gaps after and before opening the magnet, as a function of the excitation current.

Being the maximum difference at the operating current (440.4A) less than 2G (≈0.1% of the field, corresponding to a deflection error of ≈0.2 mrad) it was decided to measure the other two splitters only after the preliminary operation of opening and closing again.

Figure 2 shows the difference between the field measured at the left gap center of the series production magnets and that of the prototype. Figure 3 shows the corresponding result for the right gap (the vertical scales in the two figures are not the same). The maximum difference at the operating current is ≈3 G.

The difference between the field values in the right and left gaps are given in Figure 4. In all the magnets the absolute value of the field in the left gap (seen from the "three spheres" side) is larger than in the right one. The maximum difference at the operating current is in this case ≈5 G, corresponding to a deflection angle error of ≈0.5 mrad.

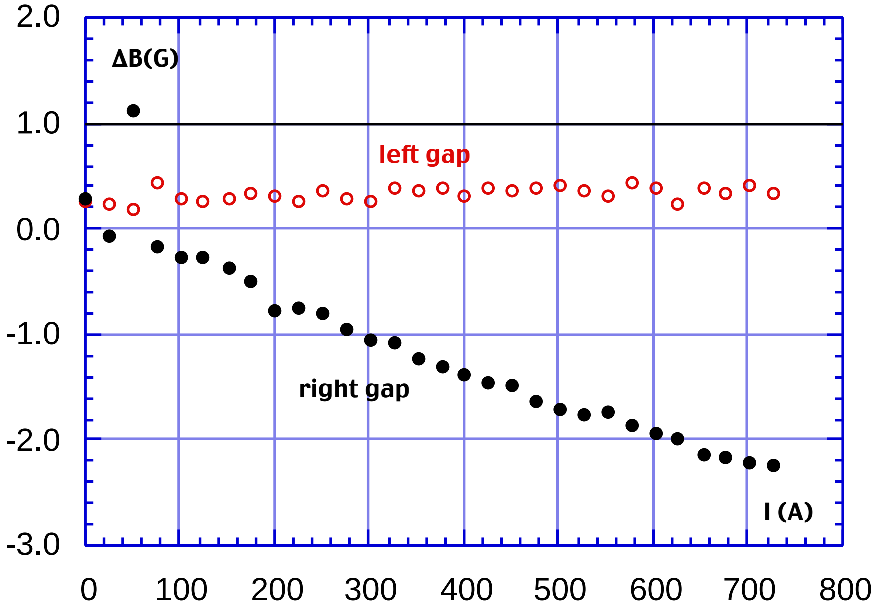

Figure 1- Difference between the field values at the center of the splitter gaps measured after and before opening the magnet

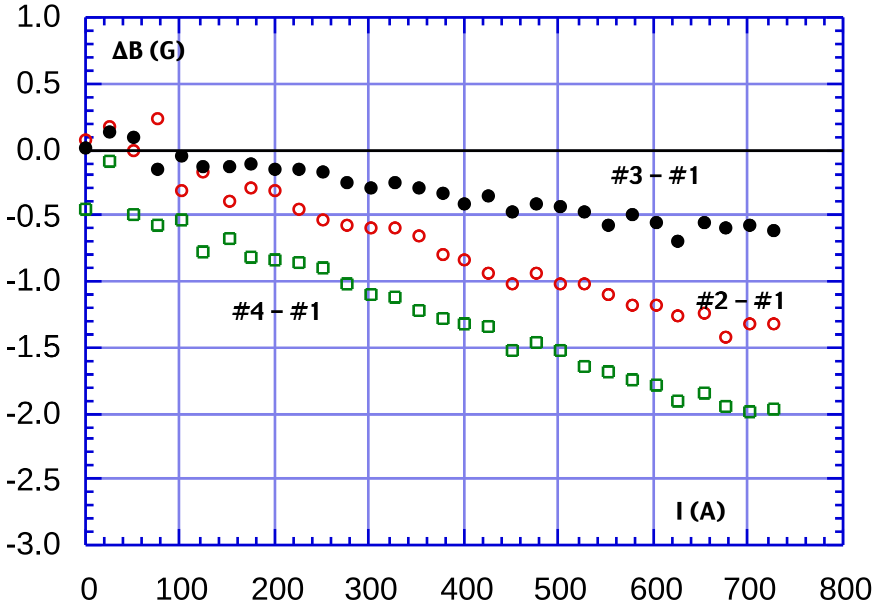

Figure 2 - Difference between the fields measured at the left gap center of each splitter and the prototype

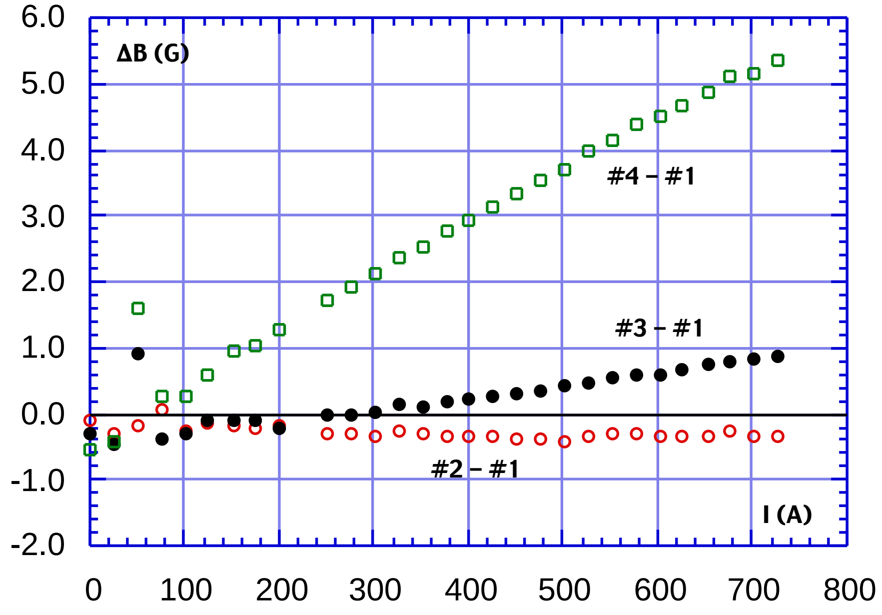

Figure 3 - Difference between the fields measured at the right gap center of the each splitter and the prototype

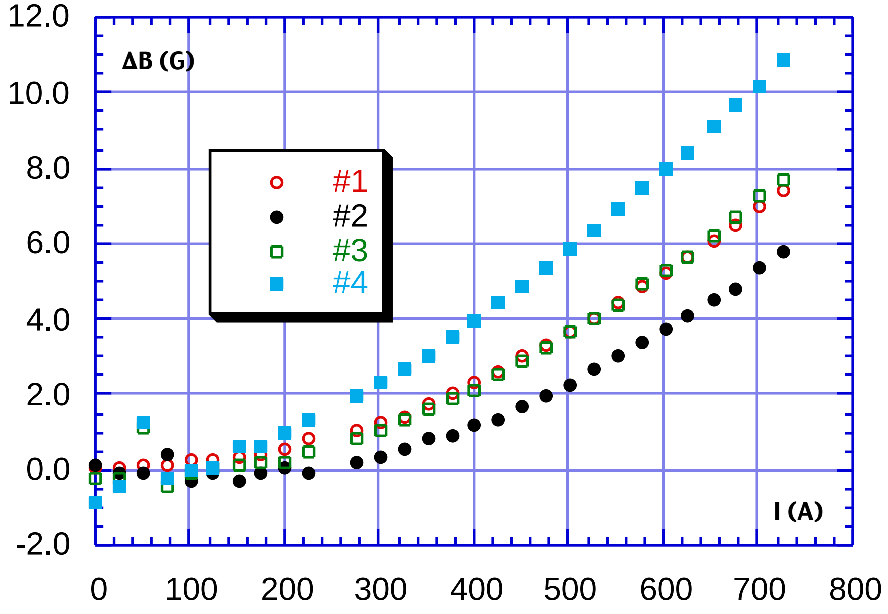

Figure 4 - Difference between the absolute values of the field in the left and right gaps

3. Longitudinal scans

In order to check the homogeneity of the field distribution inside the magnet gaps, six longitudinal scans parallel to the magnet axis have been performed on each magnet, starting from outside the fringing region where the field is almost vanishing and ending well inside the gap, where the field is constant (see Figures 6 and 7 in [1]). The scans have been taken at horizontal distances of 60, 120 and 180 mm from the longitudinal symmetry axis of the magnet in each gap. The origin of the longitudinal coordinate (y in the figures) has been set at the boundary of the iron yoke during the measurements of the series production magnets, while it was set as the position of the nominal magnetic length for the prototype (Serial#1). The difference between the two positions is 32 mm.

Figure 5 shows the field differences between the scans taken at 60 and 180 mm with respect to the scan at 120 mm (which is approximately in the center of the gap) for the prototype magnet. Figures 6, 7 and 8 are the corresponding ones for the other splitters. It can be noticed that the longitudinal axis in the prototype measurement is inverted with respect to the others (this is only due to the fact that the file has been inverted to obtain the overall field distributions shown in Figure 6 of Ref. [1])

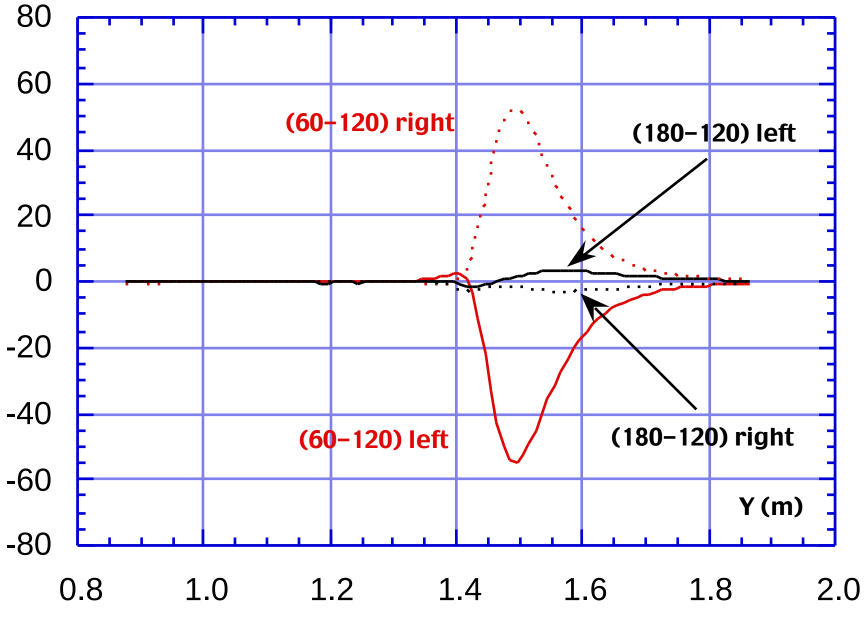

Figure 5 - Difference between the field measured along straight lines at 60 and 180 mm from the longitudinal symmetry axis with respect to the field measured along a straight line at 120 mm from the longitudinal symmetry axis. Serial #1

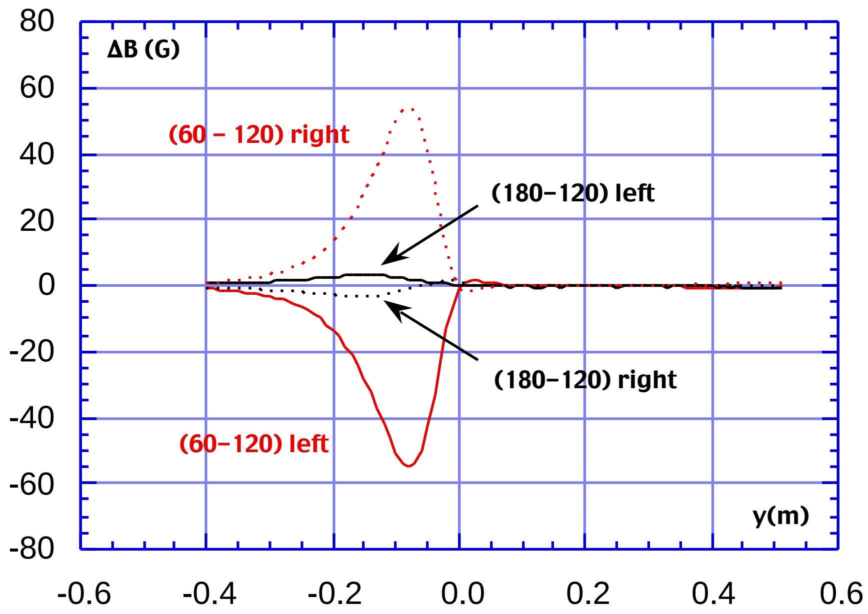

Figure 6 - Difference between the field measured along straight lines at 60 and 180 mm from the longitudinal symmetry axis with respect to the field measured along a straight line at 120 mm from the longitudinal symmetry axis. Serial #2

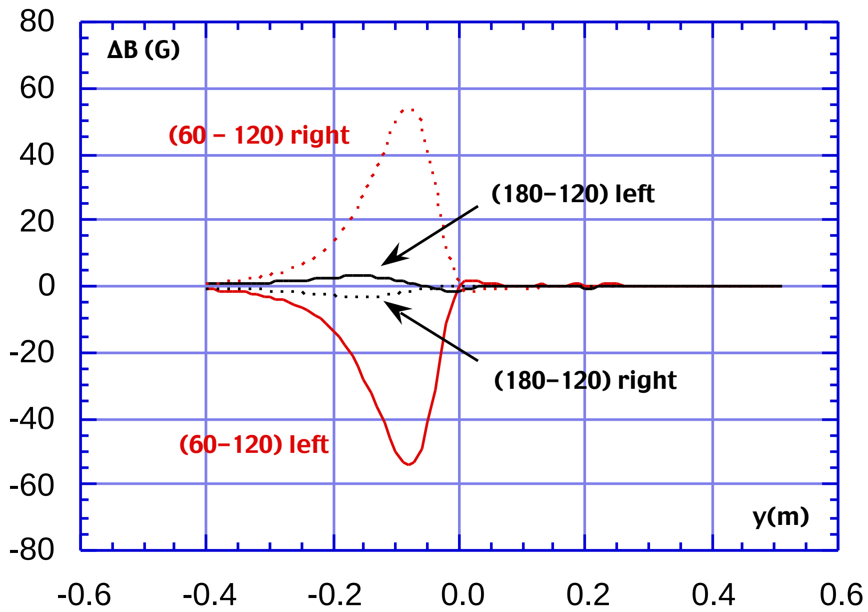

Figure 7 - Difference between the field measured along straight lines at 60 and 180 mm from the longitudinal symmetry axis with respect to the field measured along a straight line at 120 mm from the longitudinal symmetry axis. Serial #3

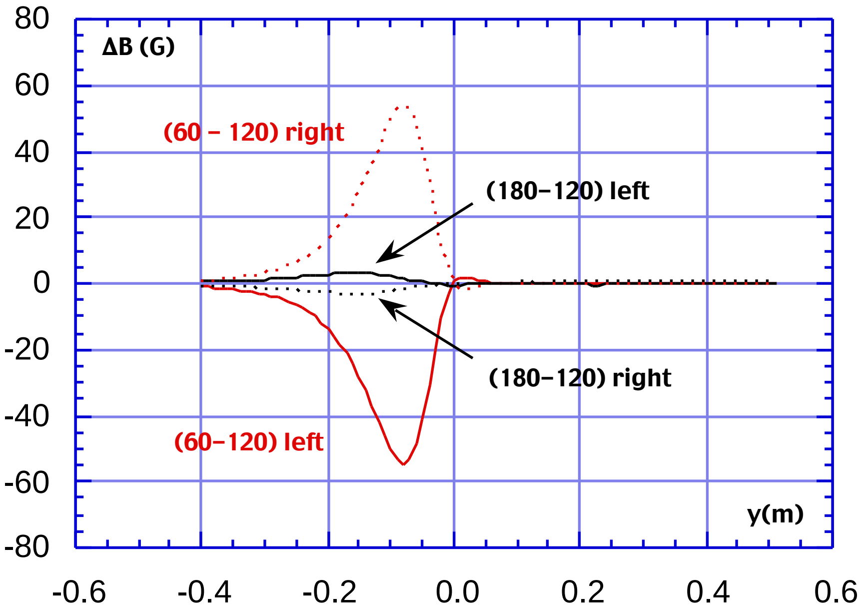

Figure 8 - Difference between the field measured along straight lines at 60 and 180 mm from the longitudinal symmetry axis with respect to the field measured along a straight line at 120 mm from the longitudinal symmetry axis. Serial #4

Observing the four figures, it appears clearly that all the measurements on the different splitters give the same results at the level of few Gauss.

4. Transverse scans

A set of transverse scans has been carried out on each magnet at different longitudinal positions, namely at the iron yoke boundary, at a distance of 75 mm from it in the fringing field region outside the yoke, at the same distance inside the yoke, and at the maximum distance inside the yoke allowed by the available span of the Hall Probe "Y" movement (500 mm inside the yoke). It is not meaningful to compare them between each other, since a small difference in the longitudinal position in the fringing region introduces a large difference in the absolute field. For this reason we only show here the behaviours of the field at the above mentioned longitudinal positions for the splitter Serial#2.

Figure 9 shows the field measured along a straight line in the horizontal symmetry plane perpendicular to the longitudinal symmetry axis at a distance of 75 mm from the iron yoke boundary outside the yoke. At this position the Hall probe does not hit any part of the magnet in the whole range of the scan and it is therefore possible to measure easily how the field changes sign passing from one gap to the other. The measurement has been performed with the two coils powered in series at the nominal current of 440.4A.

Figure 10 shows the result of the same measurement taken with the Hall probe just at the yoke boundary. In this case the scan width is limited by the coil and the Hall probe holder. The horizontal scale is therefore expanded with respect to the case of Figure 9. In addition, the sign of the field in the right gap has been inverted in order to show the field in both gaps on the same plot. The scan in Figure 11 is taken 75 mm inside the yoke while Figure 12 shows the result taken at 500 mm inside it.

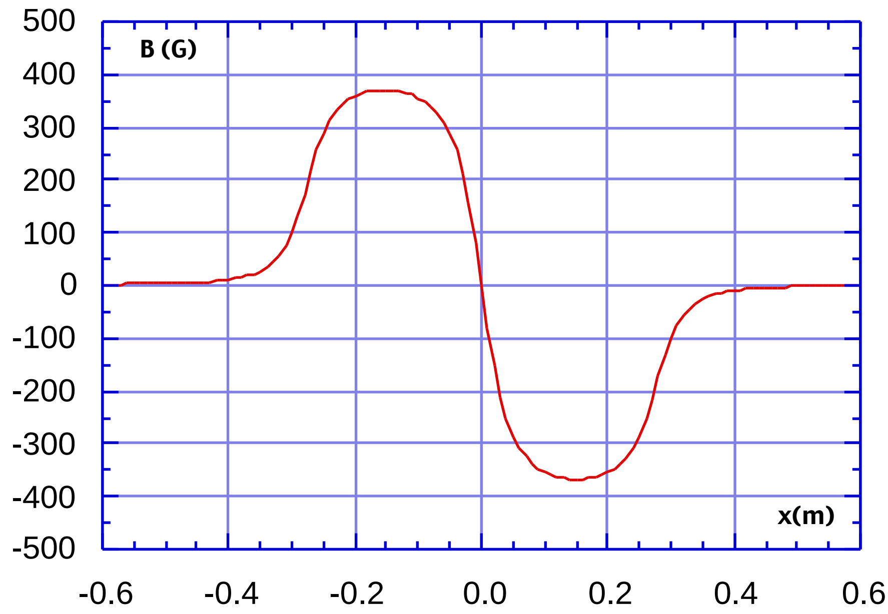

Figure 9 - Vertical field component along a straight line in the horizontal symmetry plane of Serial#2 perpendicular to the longitudinal symmetry axis at a longitudinal distance of 75 mm from the yoke boundary outside the yoke.

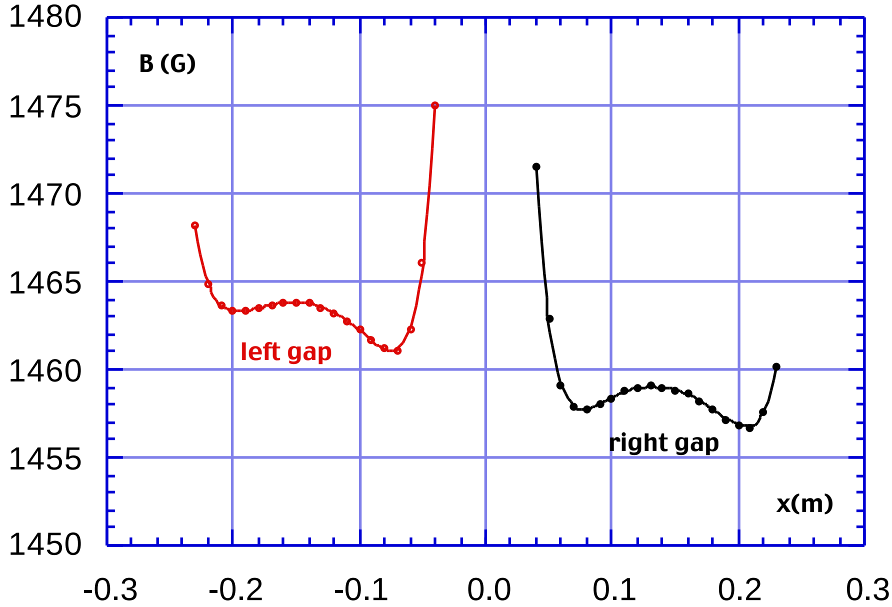

Figure 10 - Vertical field component along a straight line in the horizontal symmetry plane of Serial#2 perpendicular to the longitudinal symmetry axis below the yoke boundary. The sign of the field in the right gas is inverted.

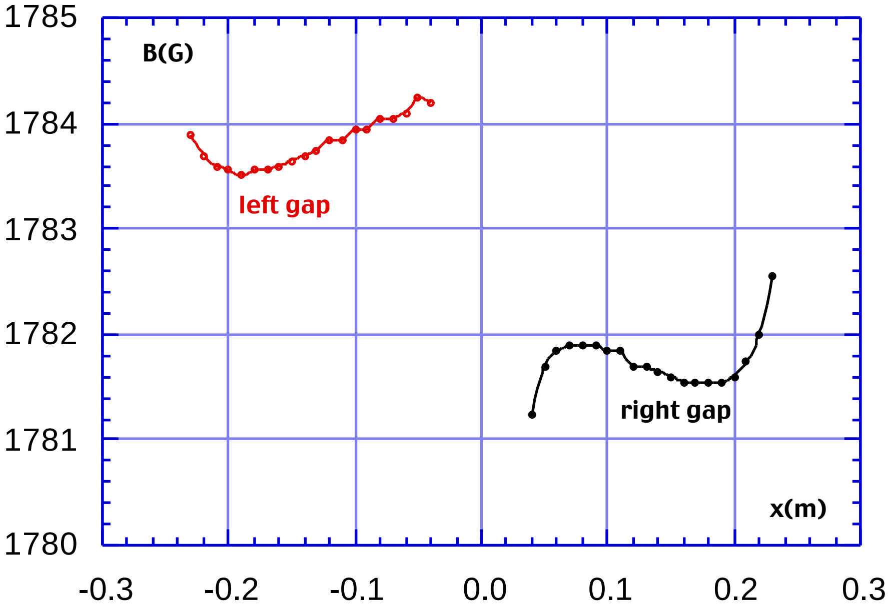

Figure 11 - Vertical field component along a straight line in the horizontal symmetry plane of Serial#2 perpendicular to the longitudinal symmetry axis inside the yoke 75 mm inside the iron. The sign of the field in the right gas is inverted.

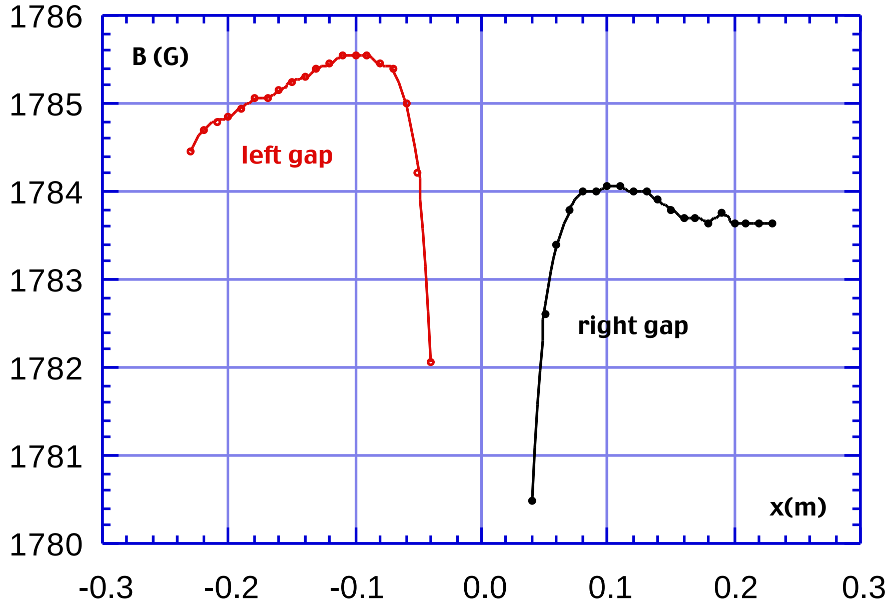

Figure 12 - Vertical field component along a straight line in the horizontal symmetry plane of Serial#2 perpendicular to the longitudinal symmetry axis inside the yoke 500 mm inside the iron. The sign of the field in the right gas is inverted.

6. Conclusions

From the point of view of the effect on the closed orbit in the DAΦNE Main Rings, the 8 gaps of the 4 splitters can be considered as equal between each other. Interpolating linearly between the averages of the results given in [1], we obtain the following relations between the beam energy and the excitation current required to bend the beam by the nominal angle in the splitter:

$$E\ (\mathrm{Mev}) = 1.16862 * I\ (\mathrm{A}) + 0.532$$

$$I\ (\mathrm{A}) = 0.85571 * E\ (\mathrm{MeV}) - 0.455$$

and therefore the operating current at the nominal operation point of the collider (510 MeV) is 435.96 A.

References

[1] C. Biscari, B. Bolli, N. Ganlin, F. Iungo, F. Losciale, M. Paris, M. Preger, C. Sanelli, F. Sardone, F. Sgamma, M. Troiani "Measurements on TESLA Splitter prototype for the DAΦNE Main Rings" - DAΦNE Technical Note MM-20 (16/12/1996).

[2] B. Bolli, N. Ganlin, F. Iungo, F. Losciale, M. Modena, M. Paris, M. Preger, C. Sanelli, F. Sardone, F. Sgamma, M. Troiani "Measurements on TESLA "Lambertson" corrector prototype for the DAΦNE Main Rings" - DAΦNE Technical Note MM-18 (3/7/1996).

[2] B. Bolli, N. Ganlin, F. Iungo, M. Modena, M. Paris, M. Preger, C. Sanelli, F. Sardone, F. Sgamma, M. Troiani "Measurements on TESLA "C" corrector prototype for the DAΦNE Main Rings" - DAΦNE Technical Note MM-17 (28/6/1996).