FIELD MAPPING FOR MISTRAL EXPERIMENT*

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Abstract

Field mapping of the magnet of the radio-frequency mass spectrometer has been performed at various field settings in view of its utilisation for atomic mass measurements, as proposed to ISOLDE Committee.

1 Introduction

It is proposed [1] to measure atomic masses of short half-lived ions produced by ISOLDE, using the Radio-Frequency Mass Spectrometer (RFMS) which had been built for PS189 experiment by a CSNSM–CERN Collaboration.

The principle of the RFMS [2] is to compare ion masses by measuring the ratio of their cyclotron frequencies while they rotate in the same homogeneous magnetic field. The field homogeneity is a critical parameter in order to reach a high resolving power, so that the magnet has been equipped with electrical current shims which allow to modify gradients or Fourier coefficients [3].

In PS189, without electrical current shims, it was possible to reach a resolving power of 3.10^5, while using these shims, the resolving power was as high as 8.10^5, demonstrating the goodness of field homogeneity. However, since PS189 aim was to compare proton-antiproton masses, the RFMS was optimized for mass 1, and field mapping only performed at 1300 G [3].

In ISOLDE proposal, a lower resolving power is assumed (10^5), but it must be available for any field up to 8000 G. This paper reports on measurements performed at various field settings from 1500 G up to 8000 G. The main goal is to deduce gradients and Fourier coefficients in order to compare them to those obtained for PS189, and to examine if electrical current shims will have to be used. A calibration of field versus coil current is also given.

2 Measurements

Field mapping was performed at CERN, using Hall probes mounted on the same mechanical system as for PS189 [3]. The data acquisition, based on a PC computer, was entirely new.

Measurements were recorded for :

•field settings B_Z = 1500, 2500, 4000, 6000, 8000 Gauss.
•angles Φ = 0, 10, 20, 30, ...,340, 350, 360 degrees (Φ=0 at modulator).
•radii R = 530, 520, 510, 500, 490, 480, 470 mm (nominal R = 500 mm).

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•altitudes z = 27, 17, 7, -3 mm (z=0 at middle plane of the magnet)
For every z, the radial component B_R is measured at z altitude while the main component B_Z is measured at z±26 mm ("probe 1" and "probe 2"). z values are indeed +53, +43, +33, +23 mm for "probe 1", and +1, -9, -19, -29 mm for "probe 2". A reference value is also recorded from a fix probe.

Furthermore, special measurements were also performed : some more detailed azimuthal and radial scans, and 2 azimuthal scans performed at different times after a "degaussing" cycle.

3 Quality of the measurements

•At low field, only the last digit is varying. It would have been nice to have one more digit recorded. However, results are coherent and significative enough at the end.
•At high field, there is a drift according to time, but the systematic normalization of measured values by the reference probe value allows to get free of it.

4 Results

4.1 azimuthal scans

Figures 1 and 2 show azimuthal scans.

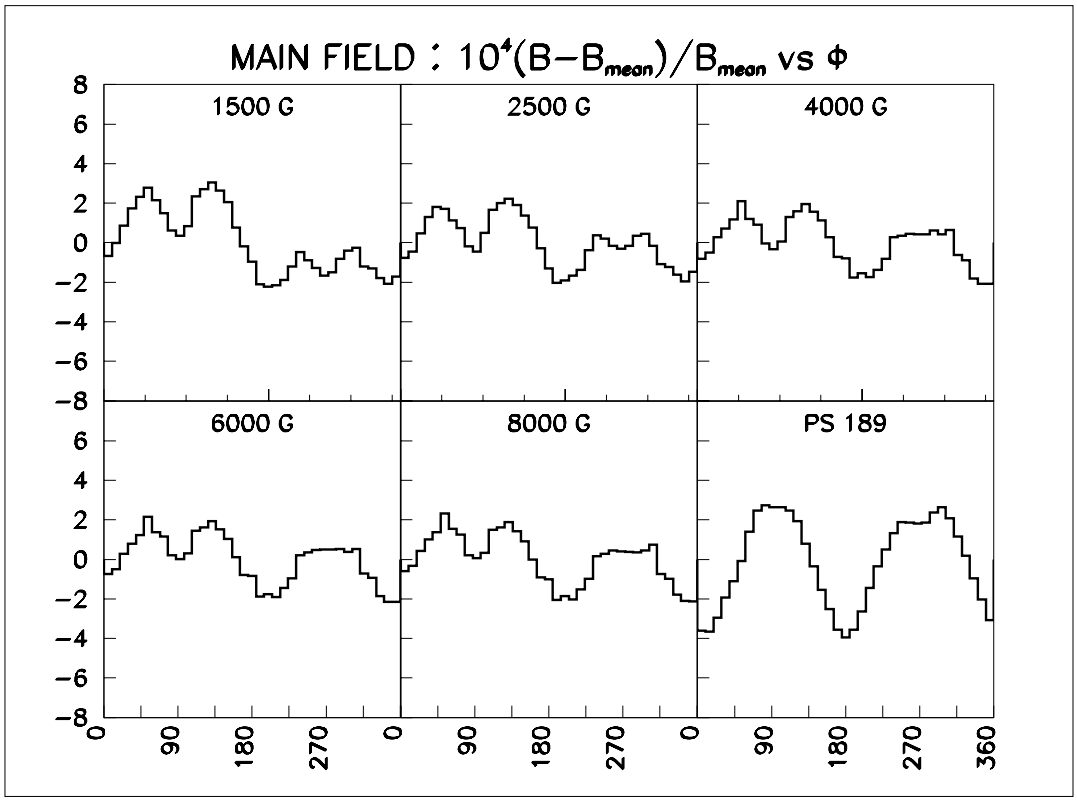

Figure 1: azimuthal scans of the main component for various field settings

Figure 1 shows B_Z variations as a function of Φ for different field settings. Each graph is the R and z average on all measurements performed for that setting. They are very similar, but different

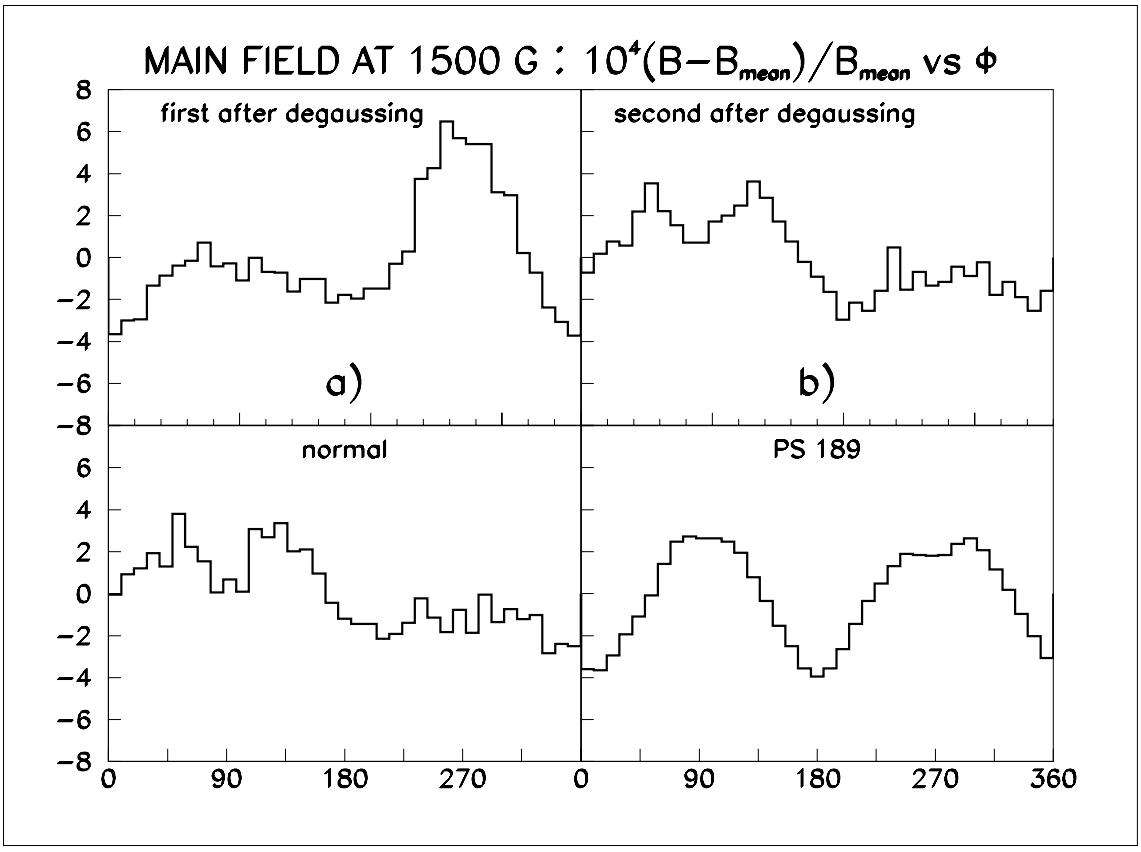

Figure 2: azimuthal scans of the main component at ∼1500 G

from that measured for PS189.

Figure 2 compares various measurements at ∼1500 Gauss. After degaussing, the two subsequent records a) and b) are very different :

•a) is unlike the other '94 measurements. As it is the first one after degaussing, it is very probable that waiting time was not long enough. It has some similarity with PS189 one, with the restriction that the two humps have very different amplitudes.

•on the contrary, b) which was recorded later, is very similar to other '94 measures, so that it may be concluded that all results are reasonably coherent.

4.2 Fourier coefficients

Fourier coefficients are defined by

$$B_Z(\Phi)/\overline{B_Z} = 1 + \sum A_n \cos n\Phi + \sum B_n \sin n\Phi$$

They are calculated for each azimuthal scan, and averaged on R, z, or R and z for each field setting (Table 1). A check has been done by averaging the field values before calculating the Fourier coefficients : results are unchanged.

As one could expect from figure 1, the coefficients are different from those determined for PS189 : A_2 is smaller while B_1 is larger :

•It appears that R and z have nearly no influence while the field setting plays a role.

•A_1 is small, similar to PS189 value. It is negligible up to 4000 G. Its value is 10^{-5} at 6000 G and 2. 10^{-5} at 8000 G.
•A_2 is small. It varies from -5. 10^{-5} at 1500 G to -9. 10^{-5} at 8000 G, while for PS189, A2 $\sim$ -28. 10^{-5}.
•B_1 is large. It varies from 19. 10^{-5} at 1500 G down to 8. 10^{-5} at 8000 G, while for PS189, B1$\sim$ 5. 10^{-5}.
•B_2 is small $\sim$ -2. 10^{-5} as for PS189.

4.3 Gradients

For every field setting, measurements were averaged on Φ and on R, or on z, in order to determine the gradients (Table 2).
•the axial gradient varies according to B from $\sim$ -3. 10^{-5} cm^{-1} at 1500 G to -25. 10^{-5} cm^{-1} at 8000 G. It agrees with the value of -2. 10^{-5} cm^{-1} measured at 1300 G for PS189.
•the radial gradient seems to be fairly constant : $\sim$ 4. 10^{-5} cm^{-1} near the nominal radius, which is the same value as measured for PS189.

4.4 Radial component

The radial component is always $\sim$ 2% of the main field.

4.5 Field calibration

Results from field calibration are given in Table 3 and plotted in Figure 3.

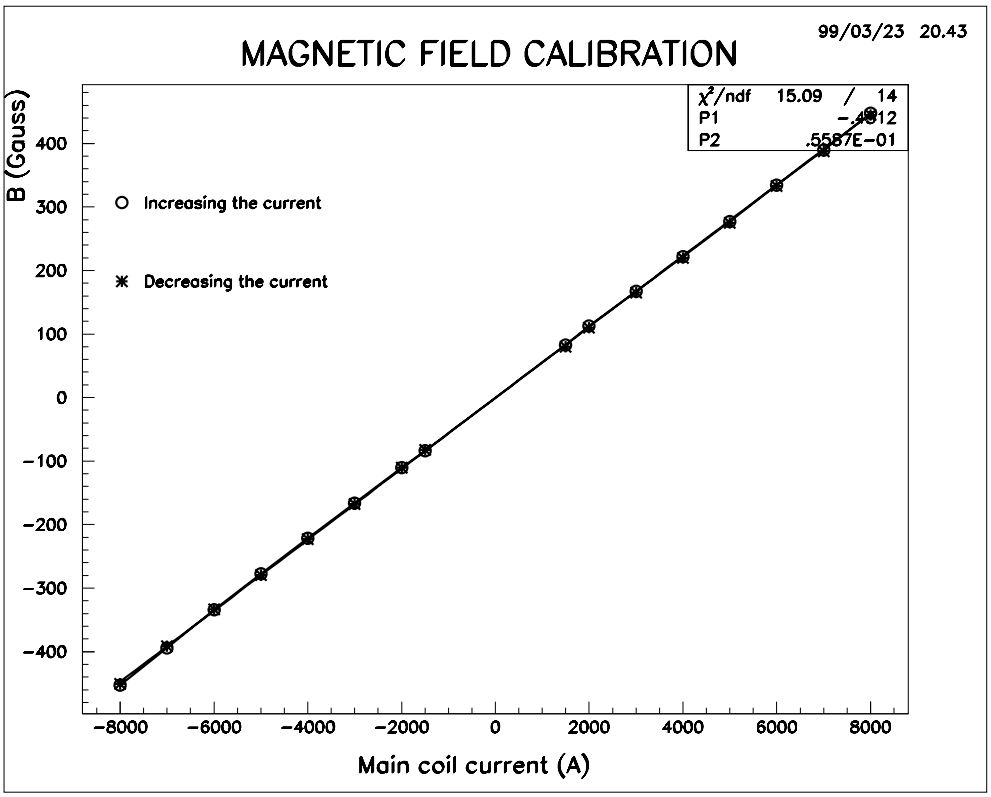

Figure 3: field calibration versus coil current intensity

5 Conclusions

• The '94 measurements are coherent, except the first measure done just after degaussing.
•the '94 Fourier coefficients are different from those measured for PS189, but the '94 values correspond to a slightly improved homogeneity.
•the gradients are very similar to those measured for PS189.

Based on the performances of PS189, we thus conclude that a resolving power of 10^5 should be reachable without using electrical current shims.

References

[1] G. Audi, G. Bollen, C. Borcea, H. Doubre, D. Guillemaud-Mueller, P. G. Hansen, B. Jonson, K. J. Kluge, G. Lebée, R. B. Moore, A. C. Mueller, G. Nyman, M. de Saint Simon, C. Thibault, H. Wollnik, ISOLDE proposal P24 : "Mass measurement of very short half-lived nuclei", CERN/ISC 93–27, ISC/P54, july 1993, addendum CERN/ISC 93–36, october 1993

[2] A. Coc, R. Le Gac, M. de Saint Simon, C. Thibault, F. Touchard "Theoretical resolving power of a radiofrequency mass spectrometer", Nucl. instr. and meth. **A271**(1988)512

[3] A. Coc, R. Fergeau, R. Grabit, M. Jacotin, J. F. Képinski, R. Le Gac, G. Le Scornet, G. Petrucci, M. de Saint Simon, G. Stefanini, C. Thibault, F. Touchard "Field mapping and corrections of the magnet of a radio-frequency mass spectrometer", Nucl. instr. and meth. **A305**(1991)143

T A B L E 1

PS189 FIELD MAPPING AT 1300 G

FOURIER COEFFICIENT FOR BZ AT Z=25 mm R=500 mm

A1 = 0.31E-04 A2 =-0.30E-03 B1 =-0.13E-04 B2 =-0.57E-04

FOURIER COEFFICIENT FOR BZ AT Z=-27 mm R=500 mm

A1 = 0.25E-04 A2 =-0.27E-03 B1 = 0.51E-04 B2 =-0.67E-06

====== 1994 FOURIER COEFFICIENTS ======

*** MEASURED FIELD VALUES WERE NORMALIZED BY REFERENCE ***

FIELD = 1500. Gauss

R average :

PROBE 1

Z = 53.mm A1 =-0.35E-05 +/- 0.26E-04 A2 =-0.65E-04 +/- 0.91E-05 B1 = 0.23E-03 +/- 0.10E-04 B2 = 0.86E-05, +/- 0.10E-04
Z = 43.mm A1 = 0.99E-05 +/- 0.22E-04 A2 =-0.66E-04 +/- 0.72E-05 B1 = 0.22E-03 +/- 0.84E-05 B2 = 0.11E-06, +/- 0.70E-05
Z = 33.mm A1 = 0.86E-07 +/- 0.19E-04 A2 =-0.69E-04 +/- 0.10E-04 B1 = 0.21E-03 +/- 0.64E-05 B2 =-0.39E-05, +/- 0.52E-05
Z = 23.mm A1 = 0.75E-05 +/- 0.55E-05 A2 =-0.62E-04 +/- 0.32E-05 B1 = 0.19E-03 +/- 0.49E-05 B2 =-0.17E-04, +/- 0.27E-05

PROBE 2

Z = 1.mm A1 = 0.61E-05 +/- 0.96E-05 A2 =-0.29E-04 +/- 0.39E-05 B1 = 0.17E-03 +/- 0.14E-05 B2 =-0.42E-04, +/- 0.22E-05
Z = -9.mm A1 = 0.22E-04 +/- 0.14E-04 A2 =-0.27E-04 +/- 0.16E-05 B1 = 0.17E-03 +/- 0.57E-05 B2 =-0.42E-04, +/- 0.53E-05
Z = -19.mm A1 = 0.16E-04 +/- 0.14E-04 A2 =-0.38E-04 +/- 0.38E-05 B1 = 0.15E-03 +/- 0.43E-05 B2 =-0.50E-04, +/- 0.60E-05
Z = -29.mm A1 = 0.15E-04 +/- 0.21E-04 A2 =-0.36E-04 +/- 0.39E-05 B1 = 0.14E-03 +/- 0.37E-05 B2 =-0.54E-04, +/- 0.83E-05

z average :

R = 530.mm A1 =-0.75E-06 +/- 0.27E-04 A2 =-0.65E-04 +/- 0.12E-04 B1 = 0.21E-03 +/- 0.16E-04 B2 =-0.23E-04, +/- 0.17E-04
R = 520.mm A1 = 0.73E-05 +/- 0.17E-04 A2 =-0.56E-04 +/- 0.86E-05 B1 = 0.20E-03 +/- 0.15E-04 B2 =-0.25E-04, +/- 0.14E-04
R = 510.mm A1 = 0.74E-05 +/- 0.98E-05 A2 =-0.49E-04 +/- 0.92E-05 B1 = 0.19E-03 +/- 0.12E-04 B2 =-0.24E-04, +/- 0.96E-05
R = 500.mm A1 = 0.11E-04 +/- 0.35E-05 A2 =-0.49E-04 +/- 0.68E-05 B1 = 0.18E-03 +/- 0.93E-05 B2 =-0.28E-04, +/- 0.94E-05
R = 490.mm A1 = 0.16E-04 +/- 0.62E-05 A2 =-0.47E-04 +/- 0.53E-05 B1 = 0.18E-03 +/- 0.12E-04 B2 =-0.22E-04, +/- 0.71E-05
R = 480.mm A1 = 0.75E-05 +/- 0.14E-04 A2 =-0.43E-04 +/- 0.55E-05 B1 = 0.18E-03 +/- 0.86E-05 B2 =-0.30E-04, +/- 0.56E-05
R = 470.mm A1 = 0.14E-04 +/- 0.23E-04 A2 =-0.35E-04 +/- 0.35E-05 B1 = 0.17E-03 +/- 0.92E-05 B2 =-0.22E-04, +/- 0.42E-05

R and z average :

A1 = 0.90E-05 +/- 0.59E-05 A2 =-0.49E-04 +/- 0.30E-05 B1 = 0.19E-03 +/- 0.45E-05 B2 =-0.25E-04, +/- 0.38E-05

FIELD = 2500. Gauss

R average :

PROBE 1

Z = 53.mm A1 =-0.17E-04 +/- 0.22E-04 A2 =-0.91E-04 +/- 0.11E-04 B1 = 0.12E-03 +/- 0.63E-05 B2 = 0.28E-05, +/- 0.70E-05
Z = 43.mm A1 =-0.13E-04 +/- 0.17E-04 A2 =-0.84E-04 +/- 0.75E-05 B1 = 0.11E-03 +/- 0.43E-05 B2 =-0.17E-05, +/- 0.72E-05
Z = 33.mm A1 =-0.59E-05 +/- 0.12E-04 A2 =-0.80E-04 +/- 0.92E-05 B1 = 0.11E-03 +/- 0.53E-05 B2 =-0.14E-04, +/- 0.37E-05
Z = 23.mm A1 =-0.38E-06 +/- 0.42E-05 A2 =-0.63E-04 +/- 0.39E-05 B1 = 0.97E-04 +/- 0.42E-05 B2 =-0.15E-04, +/- 0.40E-05

PROBE 2

Z = 1.mm A1 = 0.47E-05 +/- 0.63E-05 A2 =-0.64E-04 +/- 0.50E-05 B1 = 0.78E-04 +/- 0.27E-05 B2 =-0.32E-04, +/- 0.42E-05
Z = -9.mm A1 = 0.54E-05 +/- 0.11E-04 A2 =-0.60E-04 +/- 0.53E-05 B1 = 0.78E-04 +/- 0.26E-05 B2 =-0.32E-04, +/- 0.42E-05
Z = -19.mm A1 = 0.12E-04 +/- 0.12E-04 A2 =-0.55E-04 +/- 0.36E-05 B1 = 0.77E-04 +/- 0.36E-05 B2 =-0.41E-04, +/- 0.44E-05
Z = -29.mm A1 = 0.15E-04 +/- 0.13E-04 A2 =-0.43E-04 +/- 0.17E-05 B1 = 0.71E-04 +/- 0.32E-05 B2 =-0.33E-04, +/- 0.36E-05

z average :

R = 530.mm A1 =-0.63E-05 +/- 0.22E-04 A2 =-0.85E-04 +/- 0.11E-04 B1 = 0.96E-04 +/- 0.96E-05 B2 =-0.20E-04, +/- 0.13E-04
R = 520.mm A1 =-0.19E-05 +/- 0.15E-04 A2 =-0.79E-04 +/- 0.88E-05 B1 = 0.10E-03 +/- 0.83E-05 B2 =-0.19E-04, +/- 0.85E-05
R = 510.mm A1 =-0.29E-06 +/- 0.10E-04 A2 =-0.71E-04 +/- 0.71E-05 B1 = 0.95E-04 +/- 0.71E-05 B2 =-0.13E-04, +/- 0.80E-05
R = 500.mm A1 =-0.32E-05 +/- 0.52E-05 A2 =-0.69E-04 +/- 0.62E-05 B1 = 0.92E-04 +/- 0.84E-05 B2 =-0.23E-04, +/- 0.59E-05
R = 490.mm A1 = 0.66E-06 +/- 0.40E-05 A2 =-0.62E-04 +/- 0.46E-05 B1 = 0.88E-04 +/- 0.54E-05 B2 =-0.25E-04, +/- 0.38E-05

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R = 480.mm    A1 = 0.25E-05 +/- 0.72E-05  A2 =-0.58E-04 +/- 0.57E-05   B1 = 0.87E-04 +/- 0.46E-05  B2 =-0.22E-04, +/- 0.31E-05
R = 470.mm    A1 = 0.89E-05 +/- 0.15E-04  A2 =-0.49E-04 +/- 0.18E-05   B1 = 0.82E-04 +/- 0.46E-05  B2 =-0.22E-04, +/- 0.15E-05

R and z average :
              A1 = 0.60E-07 +/- 0.46E-05  A2 =-0.68E-04 +/- 0.30E-05   B1 = 0.92E-04 +/- 0.27E-05  B2 =-0.21E-04, +/- 0.26E-05
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FIELD =  4000. Gauss

R average :
PROBE 1
Z =  53.mm   A1 =-0.10E-04 +/- 0.12E-04  A2 =-0.91E-04 +/- 0.68E-05   B1 = 0.76E-04 +/- 0.61E-05  B2 =-0.13E-04, +/- 0.83E-05
Z =  43.mm   A1 =-0.69E-05 +/- 0.99E-05  A2 =-0.94E-04 +/- 0.48E-05   B1 = 0.73E-04 +/- 0.46E-05  B2 =-0.16E-04, +/- 0.49E-05
Z =  33.mm   A1 =-0.15E-05 +/- 0.52E-05  A2 =-0.83E-04 +/- 0.63E-05   B1 = 0.69E-04 +/- 0.33E-05  B2 =-0.20E-04, +/- 0.38E-05
Z =  23.mm   A1 =-0.31E-06 +/- 0.20E-05  A2 =-0.80E-04 +/- 0.46E-05   B1 = 0.72E-04 +/- 0.30E-05  B2 =-0.19E-04, +/- 0.42E-05
PROBE 2
Z =   1.mm   A1 = 0.14E-04 +/- 0.57E-05  A2 =-0.77E-04 +/- 0.41E-05   B1 = 0.57E-04 +/- 0.17E-05  B2 =-0.29E-04, +/- 0.19E-05
Z =  -9.mm   A1 = 0.18E-04 +/- 0.77E-05  A2 =-0.77E-04 +/- 0.29E-05   B1 = 0.57E-04 +/- 0.10E-05  B2 =-0.30E-04, +/- 0.20E-05
Z = -19.mm   A1 = 0.18E-04 +/- 0.99E-05  A2 =-0.71E-04 +/- 0.31E-05   B1 = 0.55E-04 +/- 0.62E-06  B2 =-0.30E-04, +/- 0.28E-05
Z = -29.mm   A1 = 0.20E-04 +/- 0.11E-04  A2 =-0.73E-04 +/- 0.17E-05   B1 = 0.62E-04 +/- 0.26E-05  B2 =-0.26E-04, +/- 0.22E-05

z average :
R = 530.mm    A1 = 0.10E-04 +/- 0.17E-04  A2 =-0.96E-04 +/- 0.56E-05   B1 = 0.73E-04 +/- 0.56E-05  B2 =-0.16E-04, +/- 0.70E-05
R = 520.mm    A1 = 0.86E-05 +/- 0.12E-04  A2 =-0.90E-04 +/- 0.41E-05   B1 = 0.73E-04 +/- 0.45E-05  B2 =-0.20E-04, +/- 0.61E-05
R = 510.mm    A1 = 0.95E-05 +/- 0.77E-05  A2 =-0.86E-04 +/- 0.31E-05   B1 = 0.67E-04 +/- 0.43E-05  B2 =-0.21E-04, +/- 0.45E-05
R = 500.mm    A1 = 0.36E-05 +/- 0.41E-05  A2 =-0.78E-04 +/- 0.20E-05   B1 = 0.65E-04 +/- 0.32E-05  B2 =-0.21E-04, +/- 0.32E-05
R = 490.mm    A1 = 0.20E-05 +/- 0.15E-05  A2 =-0.77E-04 +/- 0.28E-05   B1 = 0.62E-04 +/- 0.29E-05  B2 =-0.22E-04, +/- 0.11E-05
R = 480.mm    A1 = 0.68E-05 +/- 0.29E-05  A2 =-0.77E-04 +/- 0.30E-05   B1 = 0.60E-04 +/- 0.16E-05  B2 =-0.28E-04, +/- 0.24E-05
R = 470.mm    A1 = 0.46E-05 +/- 0.74E-05  A2 =-0.63E-04 +/- 0.25E-05   B1 = 0.56E-04 +/- 0.15E-05  B2 =-0.31E-04, +/- 0.20E-05

R and z average :
              A1 = 0.64E-05 +/- 0.32E-05  A2 =-0.81E-04 +/- 0.18E-05   B1 = 0.65E-04 +/- 0.15E-05  B2 =-0.23E-04, +/- 0.17E-05
================================================================================================================================

FIELD =  6000. Gauss

R average :
PROBE 1
Z =  53.mm   A1 =-0.65E-05 +/- 0.56E-05  A2 =-0.99E-04 +/- 0.44E-05   B1 = 0.78E-04 +/- 0.48E-05  B2 =-0.20E-04, +/- 0.46E-05
Z =  43.mm   A1 = 0.13E-05 +/- 0.48E-05  A2 =-0.96E-04 +/- 0.44E-05   B1 = 0.72E-04 +/- 0.32E-05  B2 =-0.21E-04, +/- 0.33E-05
Z =  33.mm   A1 = 0.55E-05 +/- 0.10E-05  A2 =-0.94E-04 +/- 0.42E-05   B1 = 0.73E-04 +/- 0.18E-05  B2 =-0.20E-04, +/- 0.24E-05
Z =  23.mm   A1 = 0.83E-05 +/- 0.24E-05  A2 =-0.88E-04 +/- 0.41E-05   B1 = 0.80E-04 +/- 0.36E-05  B2 =-0.18E-04, +/- 0.21E-05
PROBE 2
Z =   1.mm   A1 = 0.20E-04 +/- 0.57E-05  A2 =-0.88E-04 +/- 0.23E-05   B1 = 0.72E-04 +/- 0.14E-05  B2 =-0.23E-04, +/- 0.13E-05
Z =  -9.mm   A1 = 0.23E-04 +/- 0.62E-05  A2 =-0.89E-04 +/- 0.23E-05   B1 = 0.71E-04 +/- 0.17E-05  B2 =-0.24E-04, +/- 0.19E-05
Z = -19.mm   A1 = 0.23E-04 +/- 0.92E-05  A2 =-0.89E-04 +/- 0.22E-05   B1 = 0.75E-04 +/- 0.15E-05  B2 =-0.20E-04, +/- 0.10E-05
Z = -29.mm   A1 = 0.24E-04 +/- 0.89E-05  A2 =-0.87E-04 +/- 0.22E-05   B1 = 0.81E-04 +/- 0.22E-05  B2 =-0.16E-04, +/- 0.94E-06

z average :
R = 530.mm    A1 = 0.25E-04 +/- 0.12E-04  A2 =-0.10E-03 +/- 0.30E-05   B1 = 0.84E-04 +/- 0.24E-05  B2 =-0.16E-04, +/- 0.30E-05
R = 520.mm    A1 = 0.18E-04 +/- 0.83E-05  A2 =-0.99E-04 +/- 0.27E-05   B1 = 0.78E-04 +/- 0.31E-05  B2 =-0.19E-04, +/- 0.25E-05
R = 510.mm    A1 = 0.14E-04 +/- 0.65E-05  A2 =-0.98E-04 +/- 0.22E-05   B1 = 0.74E-04 +/- 0.16E-05  B2 =-0.19E-04, +/- 0.18E-05
R = 500.mm    A1 = 0.87E-05 +/- 0.40E-05  A2 =-0.90E-04 +/- 0.12E-05   B1 = 0.76E-04 +/- 0.20E-05  B2 =-0.18E-04, +/- 0.11E-05
R = 490.mm    A1 = 0.10E-04 +/- 0.18E-05  A2 =-0.90E-04 +/- 0.20E-05   B1 = 0.76E-04 +/- 0.18E-05  B2 =-0.21E-04, +/- 0.17E-05
R = 480.mm    A1 = 0.59E-05 +/- 0.11E-05  A2 =-0.85E-04 +/- 0.16E-05   B1 = 0.72E-04 +/- 0.15E-05  B2 =-0.22E-04, +/- 0.19E-05
R = 470.mm    A1 = 0.53E-05 +/- 0.34E-05  A2 =-0.78E-04 +/- 0.12E-05   B1 = 0.66E-04 +/- 0.29E-05  B2 =-0.25E-04, +/- 0.30E-05

R and z average :
              A1 = 0.12E-04 +/- 0.25E-05  A2 =-0.91E-04 +/- 0.13E-05   B1 = 0.75E-04 +/- 0.11E-05  B2 =-0.20E-04, +/- 0.89E-06
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FIELD =  8000. Gauss

R average :
PROBE 1
Z =  53.mm   A1 = 0.19E-05 +/- 0.22E-05  A2 =-0.10E-03 +/- 0.48E-05   B1 = 0.71E-04 +/- 0.42E-05  B2 =-0.20E-04, +/- 0.44E-05
Z =  43.mm   A1 = 0.16E-04 +/- 0.66E-05  A2 =-0.96E-04 +/- 0.40E-05   B1 = 0.68E-04 +/- 0.11E-04  B2 =-0.25E-04, +/- 0.13E-04
Z =  33.mm   A1 = 0.17E-04 +/- 0.10E-05  A2 =-0.90E-04 +/- 0.34E-05   B1 = 0.77E-04 +/- 0.28E-05  B2 =-0.15E-04, +/- 0.21E-05
Z =  23.mm   A1 = 0.22E-04 +/- 0.46E-05  A2 =-0.83E-04 +/- 0.27E-05   B1 = 0.95E-04 +/- 0.82E-05  B2 =-0.94E-05, +/- 0.42E-05
PROBE 2
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Z =   1.mm   A1 = 0.29E-04 +/- 0.58E-05  A2 =-0.93E-04 +/- 0.27E-05   B1 = 0.72E-04 +/- 0.37E-05  B2 =-0.20E-04, +/- 0.26E-05
Z =  -9.mm   A1 = 0.38E-04 +/- 0.53E-05  A2 =-0.93E-04 +/- 0.21E-05   B1 = 0.76E-04 +/- 0.83E-05  B2 =-0.22E-04, +/- 0.82E-05
Z = -19.mm   A1 = 0.35E-04 +/- 0.55E-05  A2 =-0.90E-04 +/- 0.20E-05   B1 = 0.91E-04 +/- 0.33E-05  B2 =-0.10E-04, +/- 0.16E-05
Z = -29.mm   A1 = 0.37E-04 +/- 0.61E-05  A2 =-0.87E-04 +/- 0.12E-05   B1 = 0.99E-04 +/- 0.38E-05  B2 =-0.74E-05, +/- 0.18E-05

z average :
R = 530.mm    A1 = 0.38E-04 +/- 0.91E-05  A2 =-0.99E-04 +/- 0.45E-05   B1 = 0.10E-03 +/- 0.76E-05  B2 =-0.55E-05, +/- 0.33E-05
R = 520.mm    A1 = 0.29E-04 +/- 0.67E-05  A2 =-0.10E-03 +/- 0.24E-05   B1 = 0.86E-04 +/- 0.33E-05  B2 =-0.12E-04, +/- 0.15E-05
R = 510.mm    A1 = 0.28E-04 +/- 0.51E-05  A2 =-0.97E-04 +/- 0.22E-05   B1 = 0.87E-04 +/- 0.24E-05  B2 =-0.97E-05, +/- 0.14E-05
R = 500.mm    A1 = 0.21E-04 +/- 0.43E-05  A2 =-0.89E-04 +/- 0.16E-05   B1 = 0.82E-04 +/- 0.39E-05  B2 =-0.12E-04, +/- 0.13E-05
R = 490.mm    A1 = 0.19E-04 +/- 0.36E-05  A2 =-0.89E-04 +/- 0.17E-05   B1 = 0.81E-04 +/- 0.27E-05  B2 =-0.16E-04, +/- 0.15E-05
R = 480.mm    A1 = 0.12E-04 +/- 0.33E-05  A2 =-0.86E-04 +/- 0.21E-05   B1 = 0.70E-04 +/- 0.48E-05  B2 =-0.23E-04, +/- 0.35E-05
R = 470.mm    A1 = 0.25E-04 +/- 0.61E-05  A2 =-0.82E-04 +/- 0.18E-05   B1 = 0.62E-04 +/- 0.11E-04  B2 =-0.35E-04, +/- 0.11E-04

R and z average :
              A1 = 0.24E-04 +/- 0.23E-05  A2 =-0.92E-04 +/- 0.12E-05   B1 = 0.81E-04 +/- 0.26E-05  B2 =-0.16E-04, +/- 0.21E-05
================================================================================================================================
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T A B L E 2

====== 1994 FIELD MAPPING ======

FIELD = 1500. Gauss

R average

z(mm)	PROBE 1	Grad. 1	PROBE 2	Grad. 2	REFERENCE
27.	0.885209+/-.000061	0.000000	0.914700+/-.000046	0.000000	-23.1578+/-.0003
17.	0.885228+/-.000052	-.000019	0.914725+/-.000040	-.000024	-23.1596+/-.0002
7.	0.885271+/-.000046	-.000043	0.914768+/-.000039	-.000043	-23.1612+/-.0002
-3.	0.885304+/-.000046	-.000034	0.914795+/-.000047	-.000027	-23.1642+/-.0004

z average :

R(mm)	PROBE 1	Grad. 1	PROBE 2	Grad. 2	REFERENCE
530.	0.885424+/-.000017	0.000000	0.914904+/-.000024	0.000000	-23.1610+/-.0020
520.	0.885401+/-.000016	0.000023	0.914873+/-.000027	0.000031	-23.1601+/-.0015
510.	0.885302+/-.000023	0.000099	0.914781+/-.000025	0.000092	-23.1607+/-.0014
500.	0.885249+/-.000018	0.000054	0.914725+/-.000018	0.000056	-23.1612+/-.0013
490.	0.885205+/-.000024	0.000044	0.914700+/-.000021	0.000025	-23.1609+/-.0012
480.	0.885131+/-.000031	0.000074	0.914643+/-.000023	0.000057	-23.1606+/-.0012
470.	0.885057+/-.000036	0.000074	0.914602+/-.000024	0.000041	-23.1606+/-.0010

R and z average :

PROBE 1	PROBE 2	REFERENCE
0.885253+/-.000025	0.914747+/-.000022	-23.1607+/-.0005

FIELD = 2500. Gauss

R average

z(mm)	PROBE 1	Grad. 1	PROBE 2	Grad. 2	REFERENCE
27.	0.884999+/-.000045	0.000000	0.915417+/-.000032	0.000000	-38.7424+/-.0002
17.	0.885046+/-.000048	-.000047	0.915462+/-.000038	-.000044	-38.7456+/-.0002
7.	0.885094+/-.000046	-.000048	0.915501+/-.000041	-.000039	-38.7506+/-.0004
-3.	0.885167+/-.000046	-.000073	0.915578+/-.000049	-.000078	-38.7553+/-.0011

z average :

R(mm)	PROBE 1	Grad. 1	PROBE 2	Grad. 2	REFERENCE
530.	0.885246+/-.000043	0.000000	0.915647+/-.000056	0.000000	-38.7470+/-.0020
520.	0.885211+/-.000035	0.000035	0.915609+/-.000039	0.000038	-38.7476+/-.0030
510.	0.885093+/-.000031	0.000118	0.915493+/-.000033	0.000116	-38.7496+/-.0033
500.	0.885078+/-.000031	0.000015	0.915473+/-.000028	0.000020	-38.7495+/-.0032
490.	0.885035+/-.000035	0.000043	0.915447+/-.000029	0.000026	-38.7490+/-.0031
480.	0.884965+/-.000034	0.000070	0.915394+/-.000025	0.000052	-38.7483+/-.0030
470.	0.884909+/-.000043	0.000056	0.915362+/-.000030	0.000032	-38.7481+/-.0027

R and z average :

PROBE 1	PROBE 2	REFERENCE
0.885077+/-.000025	0.915489+/-.000022	-38.7485+/-.0010

FIELD = 4000. Gauss

R average

z(mm)	PROBE 1	Grad. 1	PROBE 2	Grad. 2	REFERENCE
27.	0.884519+/-.000044	0.000000	0.916850+/-.000031	0.000000	-62.3683+/-.0007
17.	0.884548+/-.000044	-.000029	0.916885+/-.000036	-.000035	-62.3688+/-.0007
7.	0.884606+/-.000045	-.000058	0.916937+/-.000039	-.000052	-62.3714+/-.0005
-3.	0.884718+/-.000049	-.000112	0.917041+/-.000049	-.000104	-62.3735+/-.0007

z average :

R(mm)	PROBE 1	Grad. 1	PROBE 2	Grad. 2	REFERENCE
530.	0.884774+/-.000052	0.000000	0.917084+/-.000061	0.000000	-62.3680+/-.0010
520.	0.884712+/-.000046	0.000062	0.917032+/-.000048	0.000052	-62.3685+/-.0017
510.	0.884634+/-.000046	0.000078	0.916953+/-.000048	0.000079	-62.3701+/-.0012

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  500.    0.884594+/-.000042  0.000041    0.916909+/-.000040  0.000044    -62.3717+/-.0011
  490.    0.884546+/-.000042  0.000048    0.916880+/-.000038  0.000029    -62.3717+/-.0012
  480.    0.884481+/-.000039  0.000064    0.916831+/-.000030  0.000048    -62.3718+/-.0013
  470.    0.884443+/-.000045  0.000038    0.916808+/-.000032  0.000024    -62.3717+/-.0011

R and z average :
               PROBE 1                         PROBE 2                        REFERENCE
          0.884598+/-.000026              0.916928+/-.000023              -62.3705+/-.0005
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FIELD =  6000. Gauss

R average
  z(mm)         PROBE 1        Grad. 1          PROBE 2        Grad. 2        REFERENCE
   27.    0.883877+/-.000038  0.000000    0.918733+/-.000031  0.000000    -94.0258+/-.0009
   17.    0.883932+/-.000036  -.000056    0.918842+/-.000027  -.000109    -94.0237+/-.0012
    7.    0.884061+/-.000050  -.000129    0.918972+/-.000045  -.000130    -94.0247+/-.0012
   -3.    0.884330+/-.000072  -.000269    0.919226+/-.000062  -.000254    -94.0209+/-.0020

z average :
 R(mm)          PROBE 1        Grad. 1          PROBE 2        Grad. 2        REFERENCE
  530.    0.884250+/-.000140  0.000000    0.919118+/-.000140  0.000000    -94.0191+/-.0029
  520.    0.884134+/-.000117  0.000116    0.919012+/-.000124  0.000106    -94.0235+/-.0020
  510.    0.884104+/-.000112  0.000030    0.918985+/-.000119  0.000027    -94.0235+/-.0019
  500.    0.884066+/-.000096  0.000038    0.918947+/-.000100  0.000038    -94.0244+/-.0017
  490.    0.883992+/-.000086  0.000074    0.918892+/-.000091  0.000055    -94.0242+/-.0019
  480.    0.883916+/-.000082  0.000076    0.918831+/-.000088  0.000061    -94.0262+/-.0009
  470.    0.883886+/-.000078  0.000030    0.918817+/-.000085  0.000014    -94.0256+/-.0006

R and z average :
               PROBE 1                         PROBE 2                        REFERENCE
          0.884050+/-.000041              0.918943+/-.000041              -94.0238+/-.0007
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FIELD =  8000. Gauss

R average
  z(mm)         PROBE 1        Grad. 1          PROBE 2        Grad. 2        REFERENCE
   27.    0.883711+/-.000034  0.000000    0.920803+/-.000033  0.000000   -125.4493+/-.0011
   17.    0.883894+/-.000043  -.000183    0.921171+/-.000032  -.000367   -126.0789+/-.0547
    7.    0.884106+/-.000062  -.000212    0.921404+/-.000056  -.000234   -125.9030+/-.0142
   -3.    0.884518+/-.000103  -.000413    0.921737+/-.000076  -.000333   -125.6920+/-.0445

z average :
 R(mm)          PROBE 1        Grad. 1          PROBE 2        Grad. 2        REFERENCE
  530.    0.884307+/-.000242  0.000000    0.921480+/-.000236  0.000000   -125.6908+/-.1268
  520.    0.884208+/-.000214  0.000099    0.921408+/-.000226  0.000072   -125.7190+/-.1255
  510.    0.884095+/-.000177  0.000113    0.921308+/-.000202  0.000100   -125.7600+/-.1302
  500.    0.884038+/-.000164  0.000057    0.921254+/-.000195  0.000054   -125.7785+/-.1269
  490.    0.883978+/-.000150  0.000060    0.921214+/-.000177  0.000040   -125.7970+/-.1297
  480.    0.883907+/-.000141  0.000070    0.921157+/-.000178  0.000057   -125.8135+/-.1339
  470.    0.883866+/-.000129  0.000041    0.921132+/-.000167  0.000025   -125.9067+/-.1946

R and z average :
               PROBE 1                         PROBE 2                        REFERENCE
          0.884057+/-.000066              0.921279+/-.000070             -125.7808+/-.0484
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T A B L E 3

MAGNETIC FIELD CALIBRATION

Magnetic field (gauss)	Increasing current (A)	Decreasing current (A)
-8000	-452.5	-451.0
-7000	-393.8	-391.3
-6000	-333.8	-333.7
-5000	-277.7	-279.4
-4000	-221.8	-223.2
-3000	-166.0	-167.4
-2000	-110.6	-110.3
-1500	- 83.8	-82.6
1500	82.5	80.0
2000	112.5	110.0
3000	167.4	165.0
4000	222.0	219.5
5000	277.3	275.0
6000	334.5	332.7
7000	389.2	387.5
8000	447.5	445.0