A MEW MAGNETIC CHANNEL M9 FOR THE K500 SUPERCONDUCTING CYCLOTRON

Y.X.Xu and D.P.May

Cyclotron Institute, Texas A&M University,
College Station, TX 77843, U.S.A.

ABSTRACT

A new magnetic channel M9 is designed for improving its performance. A modelling technique is developed for this particular design. The results show that the uniformity of the field gradient in the range of 2 inches (50.8mm) around the central point is improved from 37.5% to 13% under the yoke field of 1.576kG and from 44% to 4% under the yoke field of 7.262 kG.

1. Introduction

In the K500 extraction system,M9 is the magnetic channel used to focus the beam radially as it passes through the yoke. The parameters of M9 were determined by the uniform magnetization method[1]. Since the magnetic field in the yoke penetration is no more than 7 kG,the assumption that the iron of M9 is fully magnetized was not justified. Although the original designers made some comparison between the results calculated by uniform magnetization and the ones by the TRIM code and tried to incorporate a scaling factor to obtain the actual case,they did not care too much for the uniformity of the gradient in the direction transverse to the beam in their computation for the K500 extraction system. Later, in observing the exit beam, it was noticed that it was strongly defocussed vertically (y). In recalculating the field for M9 with the POISSON code, serious non-uniformity of the field gradient in the horizontal direction transverse to the beam direction (x) was also found[2]. In the light of the recalculated results and the tuning experience,it is supposed that the deterioration of the beam quality is related to the inapropriate value of field gradient and the nonnegligible nonuniformity of field gradient of the yoke magnetic channel. In order to improve the exit beam quality an effort should be made to improve the design of the magnetic channel M9. The details will be described below.

2. Design Principle

The requirements for modifying parameters of the magnetic channel M9 may be summarized into two aspects. First of all, on the basis of analysis of the measured data the field gradient of M9 under central point field of 6 kG is 0.5 kG/in more than design level of 3.18 kG/in. This may partly be responsible for the vertical defocusing. This fact suggests that some reduction of the field gradient in M9,for example, 0.5 kG/in at high field is appropriate for an updated magnetic channel. Secondly,for a normal magnetic channel consisting of three cubic iron blocks, the field gradient distribution changes dramatically in the transverse direction. It will cause a distortion of phase ellipse of the extracted beam because of the large nonlinear term of the magnetic field. As a redesign criterion,we try to adjust the channel dimension and make a new magnetic channel with as high a uniformity as possibale.

In compliance with the extraction system design,M9 is situated in the yoke penetration. How to mimic the actual field in yoke hole becomes a key problem for designing the magnetic channel M9. After several comparisons,a special magnet was designated for simulating the stray field in the yoke penetration, as shown in Fig. 1. Since the magnetic median plane is a symmetric one only half of it is shown in Fig.1. The magnetic field distributions in the gap of the specified magnet are quite similar to the ones in the yoke penetration. The comparisons between measured results and calculated data for the original version of the magnetic channel M9 are shown in Fig.2. The good agreement within about 90% for the field gradient confirms the reliability of the simulating method.

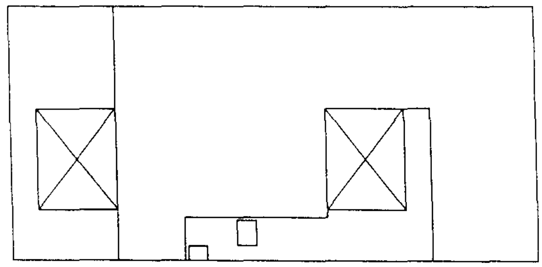

Fig.1: Layout of the special magnet for calculating the field of a magnetic channel.

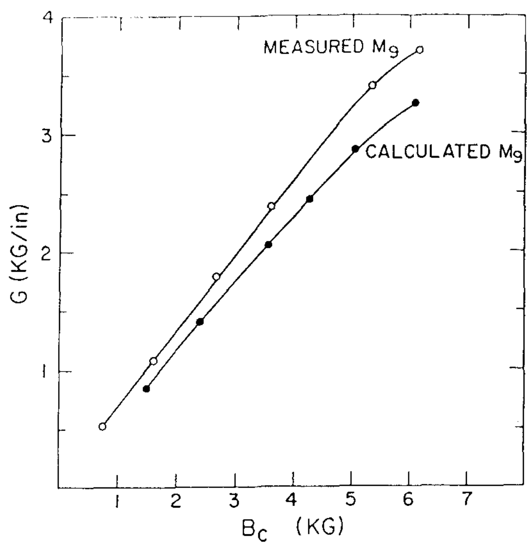

Fig.2: Comparsion between measured results and calculated data for the original magnetic channel M9. The calculation model is shown in Fig.1. B_C denotes field at the central point of M9.

3. Calculation Results

All the design calculations have been carried out using the program POISSON[3]. After trial-correction procedure,the cross section for a new magnetic channel with improved behavior was obtained as Fig.3. The 40 drgree slanted surface of the right blocks is mainly for obtaining the desired gradient of magnetic field. The 1.6 inch wide groove in the left block was designed for suppressing the quick rise of the field gradient near this region. The difference of central field gradient between the new magnetic channel and the original one is shown in Fig.4. The field gradient of new magnetic channel is somewhat lower as required by the design principle. The

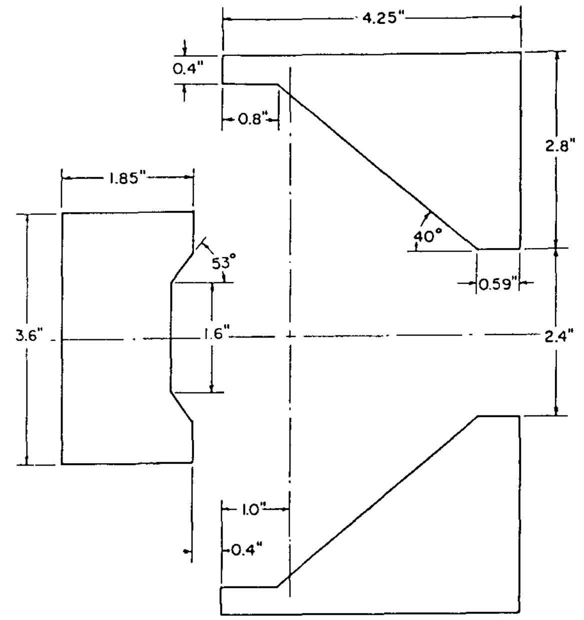

Fig.3: Schematic cross section of the new magnetic channel located in the yoke hole.

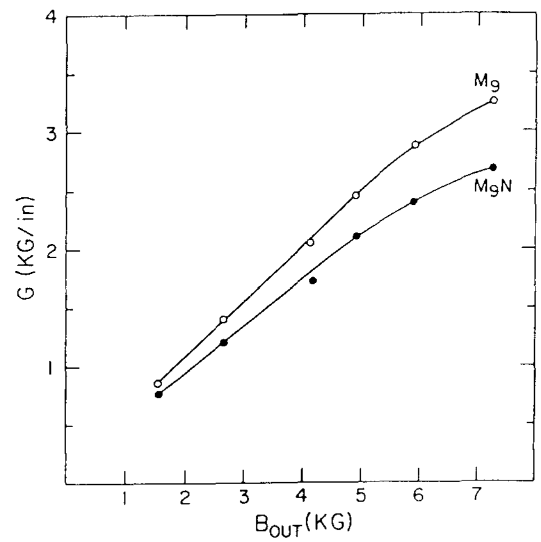

Fig.4: Difference of the field gradient between the new magnetic channel and original one as a function of outside field that refers to field in the yoke hole. M9 stands for the original magnetic channel. M9N represents new one.

gradient uniformity is compared for both cases under the yoke hole field of 7.262kG and 1.576kG respectively as shown in Fig.5 and Fig.6. The uniformity of the field gradient in the range of 2 inches around the central point is improved from 37.5% to 13% under the yoke field of 1.576 kG and from 44% to 4% under the yoke field of 7.262 kG after redesigning the magnetic channel. This great enhancement of the field uniformity for the magnetic channel M9 should make a contribution to improving the beam quality.

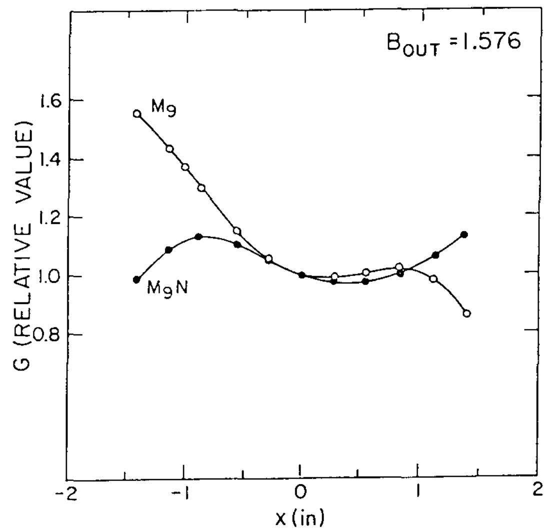

Fig.5: Field gradient distribution of magnetic channels in transverse direction under the outside field of 1.576 kG. M9 and M9N have the same meaning as Fig.4.

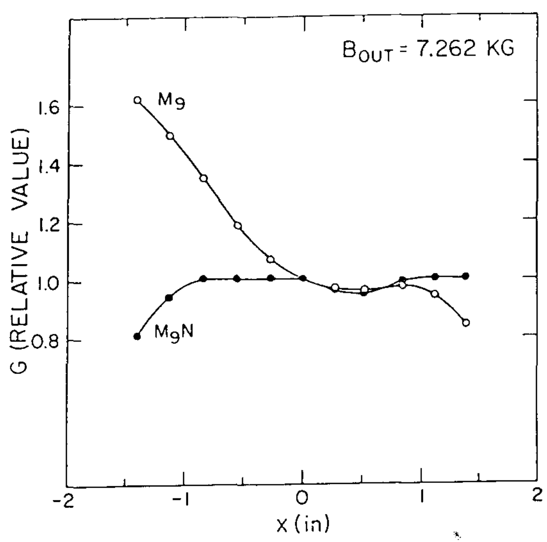

Fig.6: Field gradient distribution of magnetic channel is in the transverse direction under outside field of 7.262 kG. M9 and M9N have the same meaning as Fig.4.

References

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2. B.Milton, Annual Report of NSCL, MSU, 134(1982-1983).
3. A.M.Winslow, UCRL 7784-T (1964).