DNPL EL/TM-004

# THE MAGNET PROFILES FOR N I N A

by

V. M. Hatton & H. C. Newns.

National Institute for Research In Nuclear Science

Electron Laboratory

13th February, 1963.

# THE MAGNET PROFILES FOR N I N A

The magnet profiles of the focussing and defocussing magnets for N I N A have been calculated. The parameters which enter into the design of the profiles are the following :-

| | F | D |
|---|---|---|
| Magnetic radius | 20.77 m. | 20.77 m |
| Field index (n) | -46.169 | 47.169 |
| Gap at ideal orbit | 2.4 ins. | 3.0 ins. |
| Horizontal aperture | 13.0 cm. | 9.0 cm. |

With a magnet of finite size it is not possible to produce exactly the correct n value over the prescribed aperture. We therefore require that the n-value should be correct in this region to within certain specified limits. This can be estimated by requiring that if the n values of all the magnets are altered by this amount the working point should lie within the working diamond. This would restrict the fractional error of the field index $\Delta n/n$ to a maximum value of about 3%. So 1% seems a reasonable limit to take. However D E S Y needed to redesign their focussing magnet and in doing so tightened the limit on $|\Delta n/n|$. We are therefore guided by them in the choice of limits and choose $|\Delta n/n| \lesssim 0.6\%$ for the F-magnet and $|\Delta n/n| \lesssim 1\%$ for the D-magnet.

These requirements can be satisfied by a wide range of profiles having various widths of pole root. To keep the cost of magnet steel and the stored energy as low as possible we obviously aim for the minimum possible size. However as the width of the pole root decreases the magnetic field attained on the noses at either end of the plateau increases relative to the field on the ideal orbit and can cause saturation. This in turn can perturb the field inside the plateau and cause a reduction in aperture. The final parameter to be fixed then is the maximum field which we will tolerate on the contour. This could be done by making estimates of the perturbation of the field index in the plateau due to saturation in the noses for various maximum fields. However, we again prefer to be guided by the D E S Y experience.

The limit which they set on the contour was 1.8 times the field on the ideal orbit. With this limit they found that the final magnets performed satisfactorily even when the field in the ideal orbit reached 10,000 guass. The magnet specifications for N I N A are very similar to those of D E S Y and the maximum field required on the ideal orbit is unlikely to exceed 9,000 guass. We therefore take the value of 1.8 as the limit of the maximum field.

The profiles are now uniquely defined and can be calculated using the method given by Hardt[1], to which reference can be made for details of the method. A complete account of the method as applied to the calculation of the N I N A magnets has been given by V. M. Hatton.[2] The calculation of the profile of the F-magnet was carried out using the various requirements as detailed above. In the case of the D-magnet, however, a slight deviation was made. The conditions could have been satisfied with a profile having a smaller pole root than the F-magnet. Since it is convenient to keep the overall size of the laminations the same for both magnets it was decided to design the D-magnet with roughly the same pole root as the F-magnet. This enabled us to reduce the value of the maximum field on the contour of the D-magnet. This is very satisfactory since the D-magnet is more sensitive to saturation effects than the F-magnet. The final values for the magnetic field were 1.7 on the nose of the closed side and 1.6 on the nose of the open side.

In calculating the profiles of either magnet it is assumed that the left hand and right hand faces of the magnet are independent and so are calculated separately. In the case of the F-magnet this is certainly so and the two halves join perfectly at the position of the ideal orbit. In the case of the D-magnet they are not independent. However the deviations of the field index due to each half tend to cancel out. The two halves of the contour did not join quite perfectly in the case of the D-magnet, there being a slight step at the position of the ideal orbit. This was in fact far less than the accuracy to which the die could be made but it was in any case removed by reducing the vertical coordinates of every point on one half of the contour by this amount. When this was done there was still a slight change in slope at this point. This again was so small that it would be washed out in the making of the die and so no further smoothing was done.

The shape of the contours for the F and D-magnets are shown in the figures at the end of this note together with a plot of $\Delta n/n$ across the plateau.

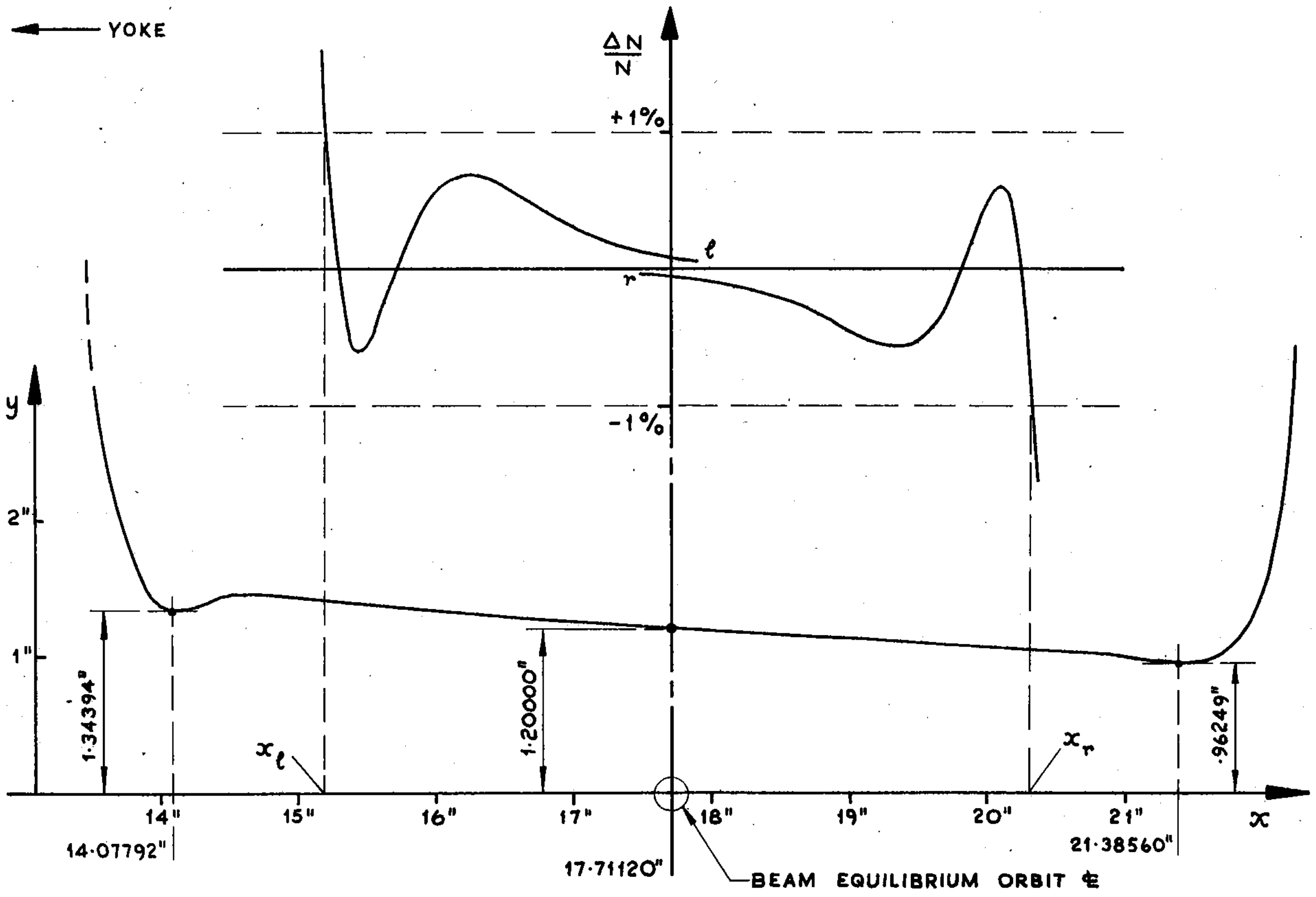
References.

1. Hardt, W. D E S Y Report A 1.5 "Über die Gestaltung des D E S Y-Magneten".
2. Hatton, V. W. M.Sc.Thesis. "The Pole Contour Design for the National Institute Electron Synchrotron".

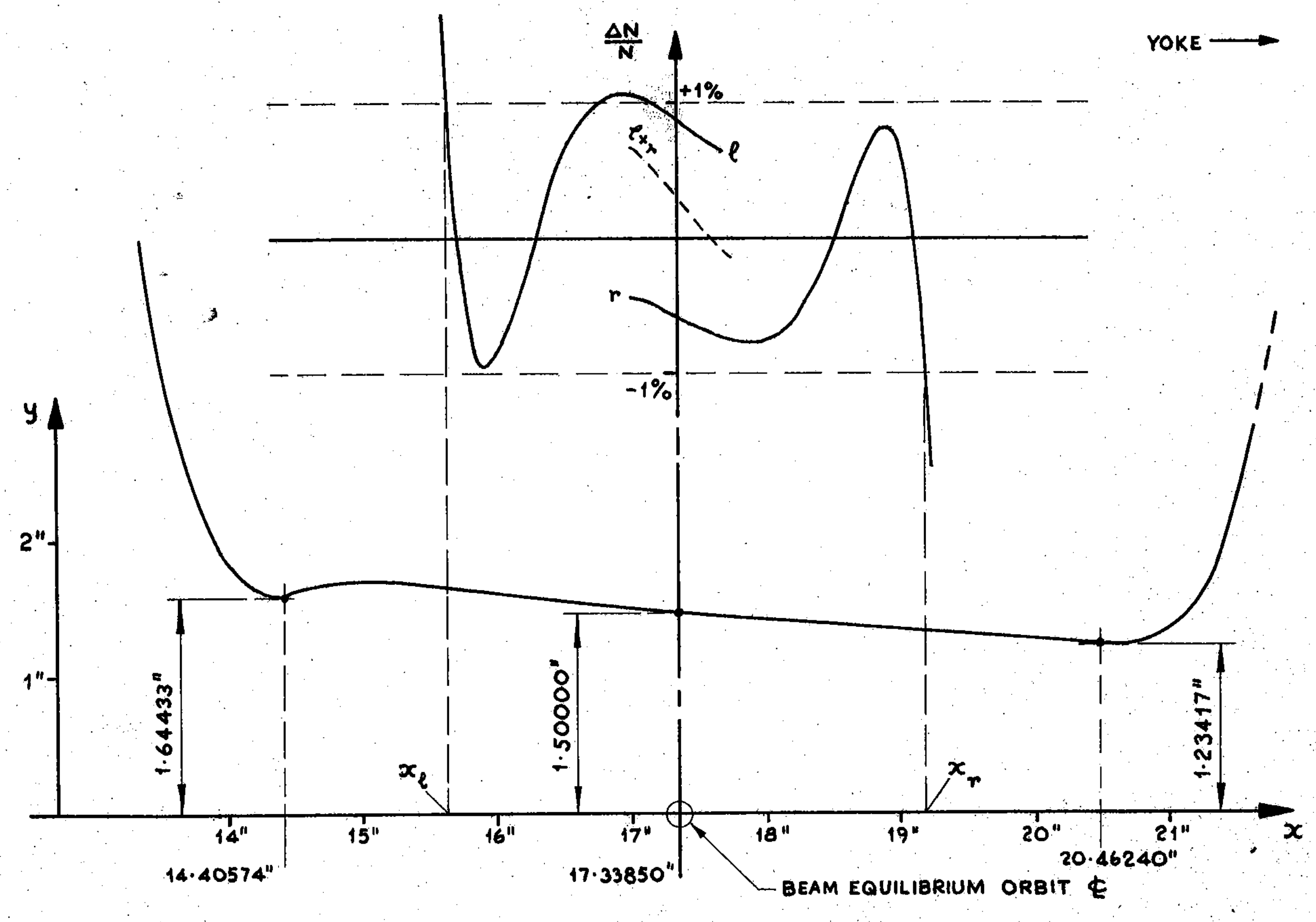
Acknowledgments.

This work would simply not have been possible without the report by Hardt upon which it is entirely based. In addition one of us (H.C.Newns) is very grateful to Dr. Hardt and Dr. Wüster for a couple of conversations which greatly amplified and clarified the procedures used.

EL/TM.4.
13.2.63.




Variation of field index across plateau for 'F' Magnet




Variation of field index across plateau for 'D' Magnet