DAΦNE TECHNICAL NOTE

INFN - LNF, Accelerator Division

Frascati, Sept. 20, 1991

Note: **M-3**

IRON FREE PERMANENT MAGNET QUAD CROSS SECTION

A. Cattoni

The low-β quadrupoles for DAΦNE have to give the wanted gradients and field quality on a maximum possible inner aperture and keeping the over all outer dimensions below the limits imposed by the detector (and by the machine itself). To see quickly were we can stand with the design, the following assumption have been made:

1) Quadrupole cross section geometry as the Halbach model (see Fig. 1).

2) Eq. 1)[1,2] $G = 2\eta B_r \cdot (1/r - 1/R)$

η = 0.94 for a 16-block Quadrupole;
B_r = 1 T for SmCo p.m.
r = active material inner radius;
R = active material outer radius.

3) Let us call r_1 and R_2 respectively the effective bore aperture radius and the over all external radius of the Quad, taking into account the geometry given in Fig. 1 and the limits imposed by the detector.

For all the quads we can put

$$r_1 = r - 0.03\,r = 0.97\,r$$

due to the thickness of the inner containing ring of the p.m.

For the first quad, put at 0.45 m from the I.P., we can suppose that no constraints are given by the current sheets thickness at the quad starting point.

So we can write:

$$R_2 = R + 0.15\,R = 1.15\,R$$

due to the p. m. fixtures and external collar thickness.

The given definition of the parameter R_2 is valid for all the quadrupoles of concern, but the numerical value to adopt in the calculations will be, for the second and third quad a number taking into account the shielding solenoid thickness, that in the last detector version (B=0.7 T) should be not less than 25 mm including the support cylinder.

Let us assume 28 mm to have a certain clearance for the quad centering system. So the limits for the R_2 parameter are:

Minimum R_2 $= 0.45$ tang. $(8.5°) = 0.067$ m

Maximum R_2 $= 1.23$ tang. $(8.5°) - 0.028 = 0.184 - 0.028 = 0.156$ m

Now, after the above consideration, the equation 1) can be written:

$$G = 2\eta B_r \,.\, (1/r - 1/R) = 1.88\,(0.97/r1 - 1.15/R_2)$$

$$G = 1.82/r_1 - 2.16/R_2$$

Three families of curves can be plotted and are represented as follows:

Fig. 2	$G = f(r_1)$	parameter R_2
Fig. 3	$G = f(R_2)$	parameter r_1
Fig. 4	$R2 = f(r_1)$	parameter G

The family of curves plotted in Fig. 4 has been limited to gradient values which are interesting for the low-β insertion quadrupoles of DAΦNE.

References

1) N.I.M. 169 (1980) K.Halbach: Design of Permanent Multipole Magnets with oriented Rare Earth Cobalt Material.

2) Asymmetric B Factory Collider Note ABC-18 (K. Halbach Sept.25, 1990).

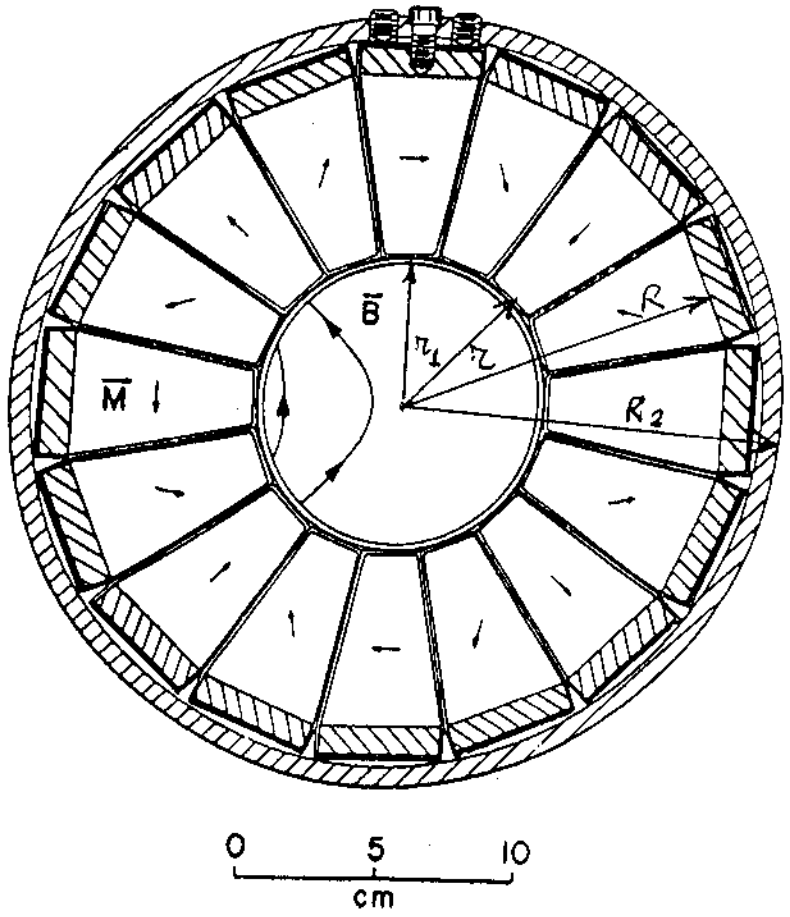

Fig. 1 - Section of Rare Earth Cobalt Permanent Magnet Quadrupoles

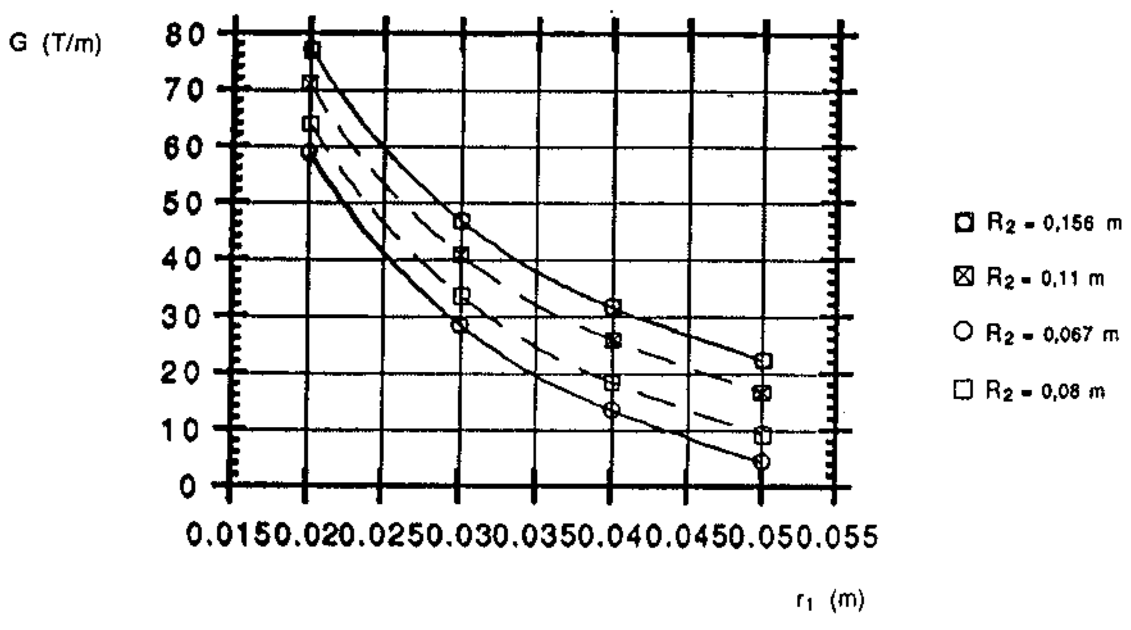

Fig. 2

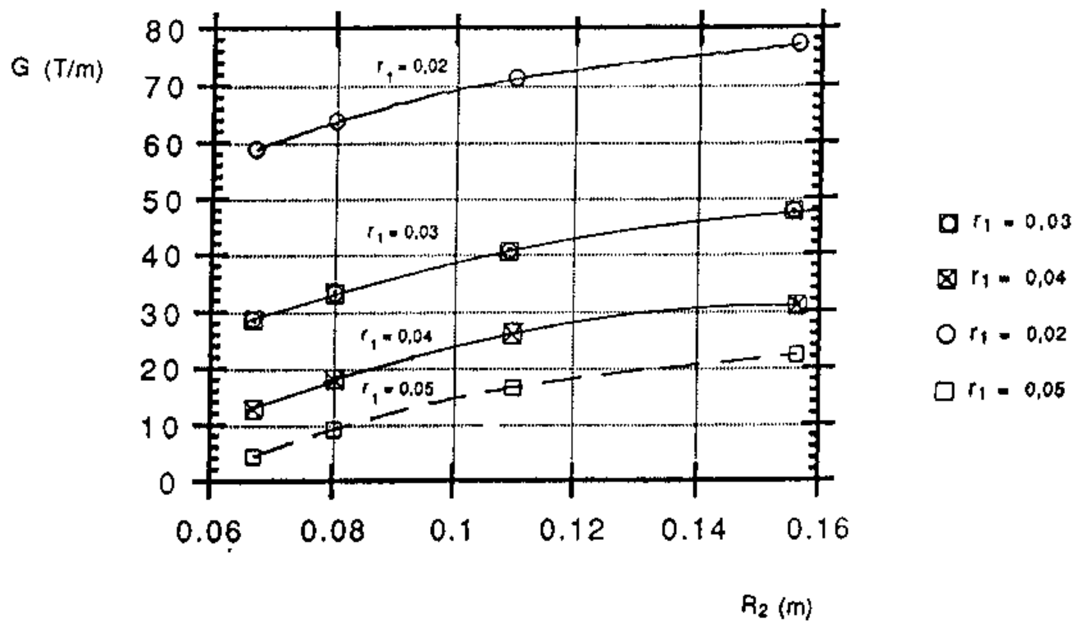
G (T/m)
80
70
60
50
40
30
20
10
0
r1 = 0,02
r1 = 0,03
r1 = 0,04
r1 = 0,05
0.06
0.08
0.1
0.12
0.14
0.16
R2 (m)
r1 = 0,03
r1 = 0,04
r1 = 0,02
r1 = 0,05

Fig. 3

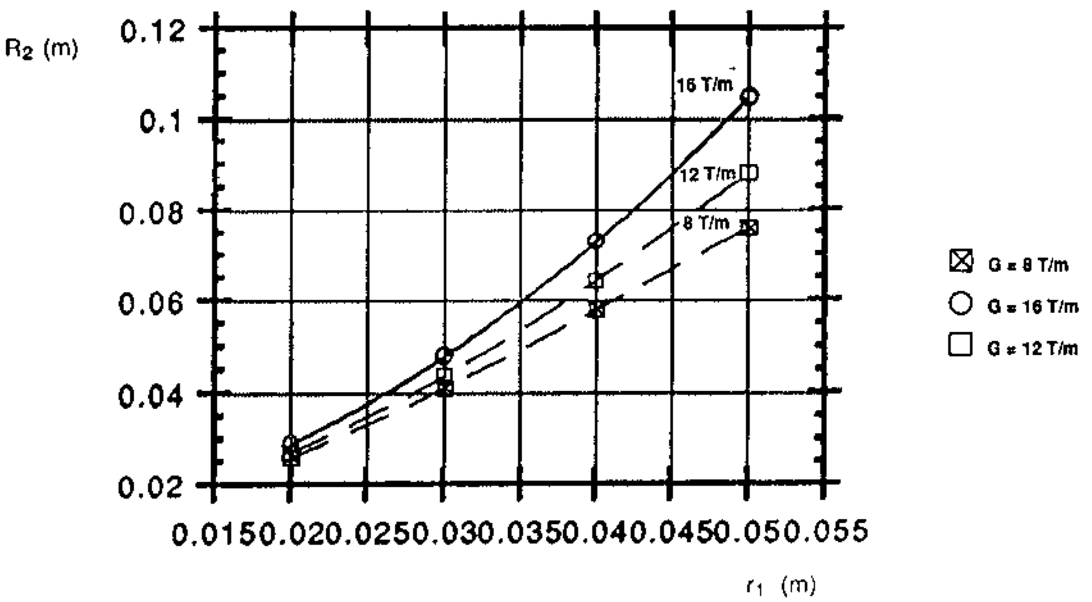
R2 (m)
0.12
0.1
0.08
0.06
0.04
0.02
16 T/m
12 T/m
8 T/m
0.0150.020.0250.030.0350.040.0450.050.055
r1 (m)
G = 8 T/m
G = 16 T/m
G = 12 T/m

Fig. 4