DAΦNE TECHNICAL NOTE

INFN - LNF, Accelerator Division

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Note: **M-2**

QUICK DIMENSIONING FOR AN HYBRID TYPE QUADRUPOLE

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The hybrid quadrupole is a good candidate for the DAΦNE interaction region, and a prototype is presently under construction at Ansaldo Ricerca.

The cross section of such a quadrupole is shown in Fig. 1.

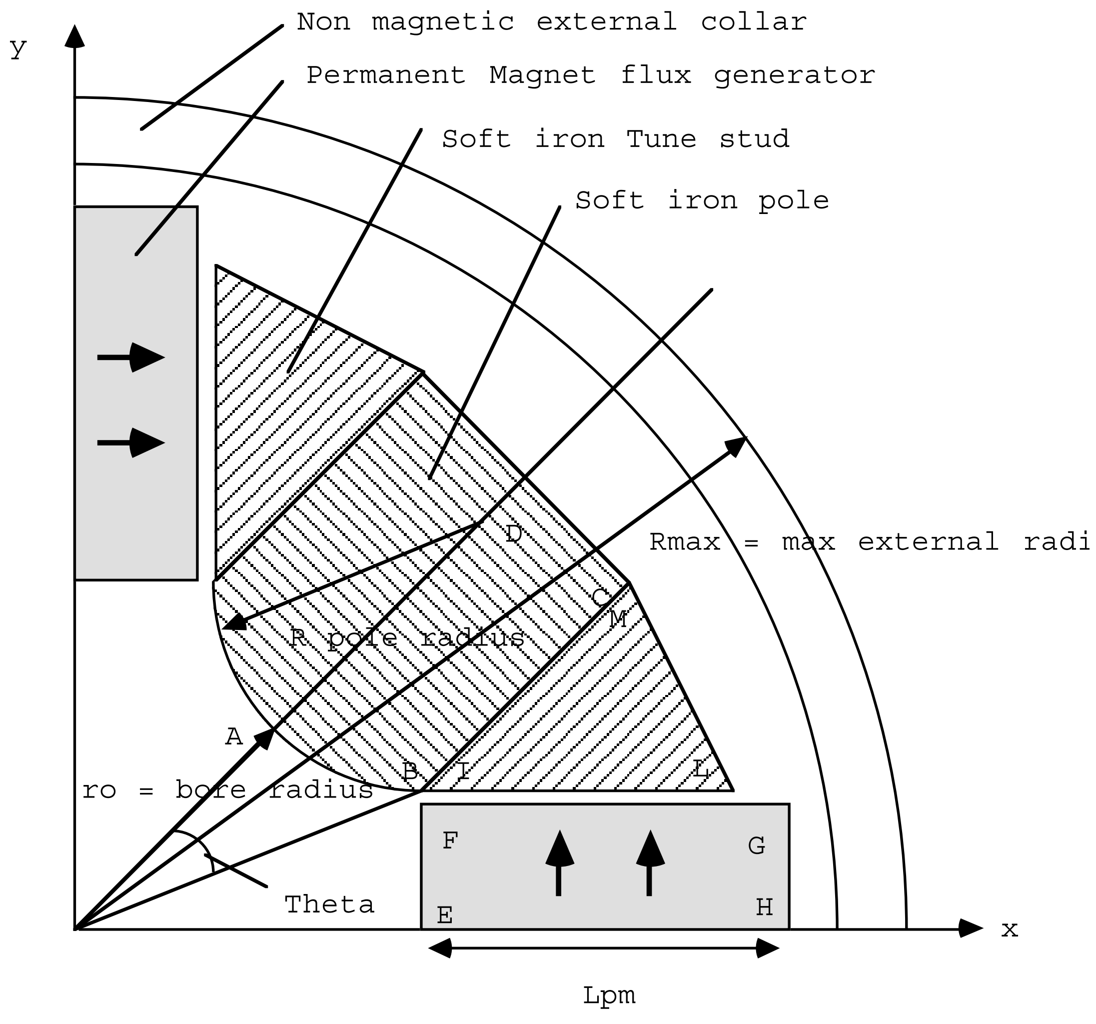

Fig. 1 - Hybrid Quadrupole geometry.

In Fig. 2 the gradient of the hybrid quadrupole vs. the inner bore r_o and for different external radii is shown.

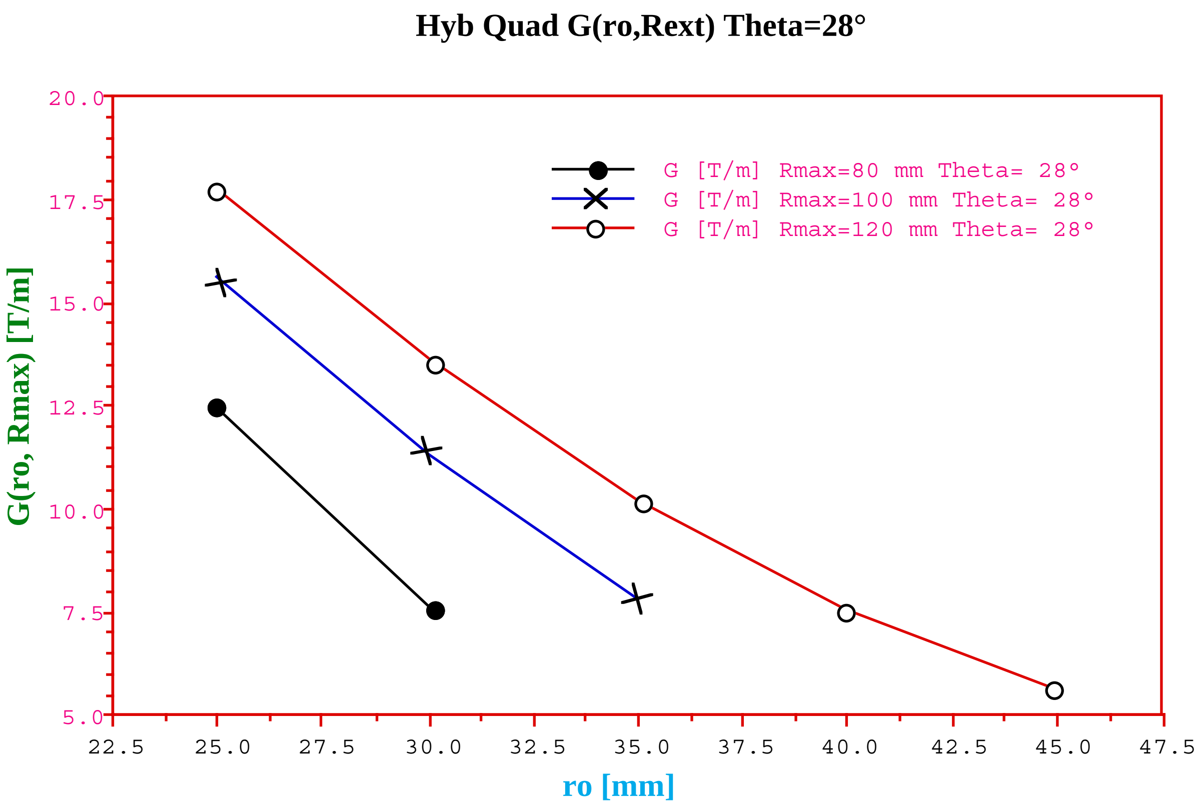

Fig. 2 - The gradient as calculated by Poisson for different bore and external radii.

APPENDIX

In the following we give more details on how the magnetic field values are derived. All the calculations are made with the 2-D code Poisson under the following assumptions:

1) 2 mm gap has been considered between the permanent magnet and the tune stud to take in account the thickness of the wall of the box containing the permanent magnets;

2) the maximum external dimension of the permanent magnets has been limited to $0.85 * R_{max}$, to take into account the thickness of the external collar that has been assumed $0.15 * R_{max}$;

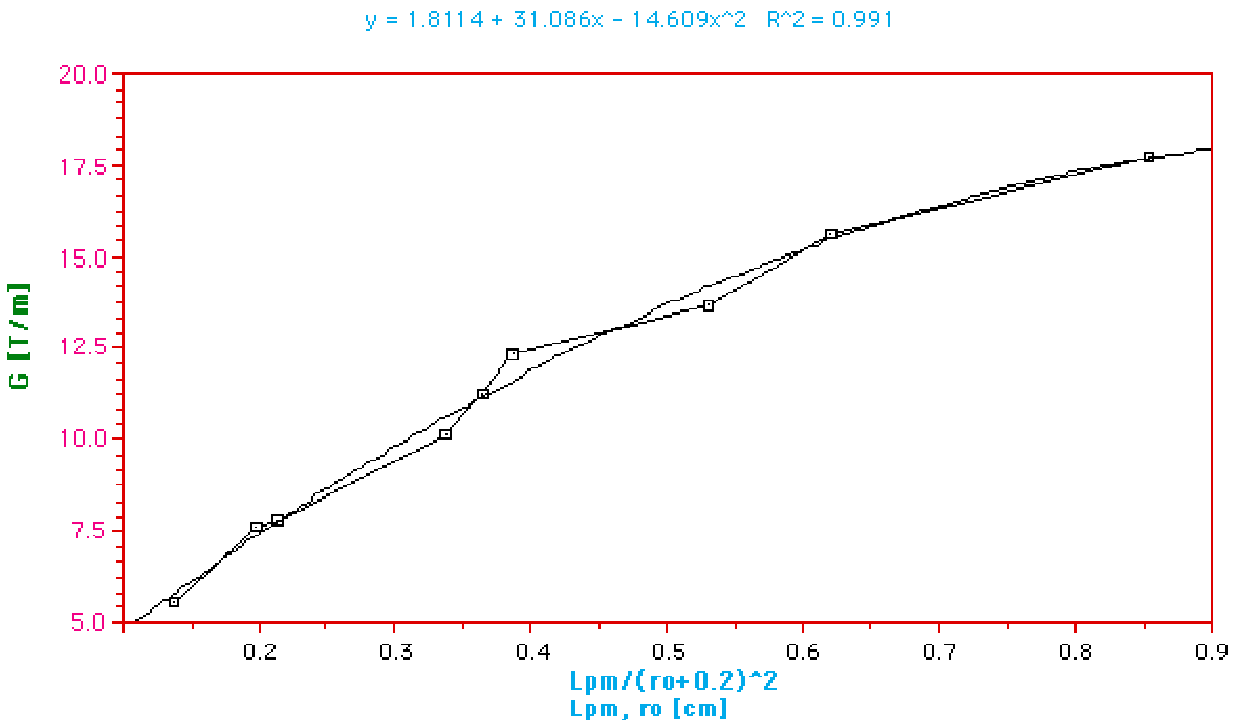

Fig. 3 - The gradient as function of the parameter Lpm/(r_o+0.2)^2.

3) the permanent magnets, as in the hybrid undulators, have been considered overhanged with respect to the tune studs; a 20% of the full width of the p.m. has been considered overhanged;

4) in the following, bore radii ranging from 25 to 45 mm and gradients ranging from about 5 to 17 T/m have been considered;

5) the angle theta has been assumed 28°;

6) the permanent magnets have been assumed to have H_c = 9000 O_e and B_r = 10200 Gauss;

7) the iron is the 1001 steel.

The following formulas give the coordinates of the points shown in Fig. 1 (r_o, R_{max} must be in mm).

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$$x_A = \frac{r_o}{\sqrt{2}}$$

$$y_A = \frac{r_o}{\sqrt{2}}$$

$$x_B = r_o \cdot \frac{\cos\theta \cdot \cos(45 - \theta)}{1 - \sin\theta}$$

$$y_B = r_o \cdot \frac{\cos\theta \cdot \sin(45 - \theta)}{1 - \sin\theta}$$

$$x_C = 0.48 \cdot R_{max} + 0.434 \cdot r_o \cdot \frac{\cos\theta \cdot \cos(45 - \theta)}{1 - \sin\theta}$$

$$y_C = 0.48 \cdot R_{max} + r_o \cdot \frac{\cos\theta}{1 - \sin\theta} \cdot (\sin(45 - \theta) - 0.565 \cos(45 - \theta))$$

$$x_D = 0.48 \cdot R_{max} + r_o \cdot \frac{\cos\theta}{1 - \sin\theta} \cdot (0.434 \cos(45 - \theta) - 0.707 \sin\theta)$$

$$y_D = x_D$$

$$x_L = 0.68 \cdot R_{max} + 0.2 \cdot r_o \cdot \frac{\cos\theta \cdot \cos(45 - \theta)}{1 - \sin\theta}$$

$$y_L = y_B$$

$$x_E = x_B$$

$$y_E = 0.0$$

$$x_F = x_E$$

$$y_F = r_o \cdot \frac{\cos\theta \cdot \sin(45 - \theta)}{1 - \sin\theta} - 2$$

$$x_G = 0.85 \cdot R_{max}$$

$$y_G = y_F$$

A certain number of possibilities have been analyzed by means of Poisson and in Fig. 2 the results obtained for three different external radii (80, 100, 120 mm) are plotted.

In Fig. 3 the gradient vs. the length of the permanent magnets is also shown: the squares correspond to the gradients as calculated by Poisson, while the solid line is a best fit with a second order polinomial:

$$G = 1.8114 + 31.086 \frac{Lpm}{(r_o + 0.2)^2} - 14.609 \left(\frac{Lpm}{(r_o + 0.2)^2} \right)^2$$

The extrapolation outside the region of Fig. 2 is good within 10%.