DAΦNE TECHNICAL NOTE

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Note: **I-5**

A NEW WORKING POINT FOR THE DAΦNE ACCUMULATOR

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1. INTRODUCTION

High order multipoles in the magnetic field of a storage ring may strongly reduce the dynamic aperture and their effect depends also on the choice of the betatron tunes. The structure presented in Ref. [1] was particularly sensitive to octupole and decapole components in the bending magnets. A new working point has been therefore studied to relax the tolerances on the magnetic elements design. In this report we present the new lattice and the results of non linear tracking with multipole components.

2. THE NEW MAGNETIC LATTICE

The original lattice [1] was prone to octupole and decapole components in the bending magnets, limiting the tolerance on their field error $\Delta B/B$ at a value of $\approx 10^{-4}$ at 3 cm from the center.

Fig. 1 shows the resonance plot, up to the dodecapole, for one machine period (the ring is composed of two symmetric cells), since we are now studying the effect of systematic multipoles in the magnetic elements. It can be clearly seen that the previous working point **[Q_x/cell = 1.445, Q_y/cell = 0.565]** sits in the neighbourhood of "dangerous" resonance lines. The presence of multipoles can therefore easily drive instabilities in betatron oscillations, thus badly affecting the dynamic aperture. We looked therefore for a new working point (w.p.) in an area more free of resonances, the chosen w. p. being **Q_x/cell = 1.445, Q_y/cell = 0.455**; the horizontal betatron tune is unchanged with respect to the previous one, thus leaving the injection parameters practically the same.

The optical functions for 1/4 of the ring are plotted in Fig. 2. Table I shows the updated parameter list. The mechanical layout of the accumulator has not been changed with respect to the previous one [1]. The new w.p. is obtained by simply changing the quadrupole gradients. The sextupoles are varied accordingly to drive the chromaticity to +1 in both planes. Table II shows the new magnetic structure, no changes being made in bending magnets.

Fig. 3 shows the dynamic aperture for the ideal machine calculated in the center of the injection straight section for particles with nominal energy and with $\Delta E/E = \pm 1.5$ %.

Comparing this plot with the corresponding one for the old w.p., a reduction of the maximum oscillation amplitude in the vertical plane can be noticed. However, this reduction is not harmful if we consider that the vertical stable region exceeds in any case the required aperture, ±12 mm in the vertical plane and ±16 in the horizontal one.

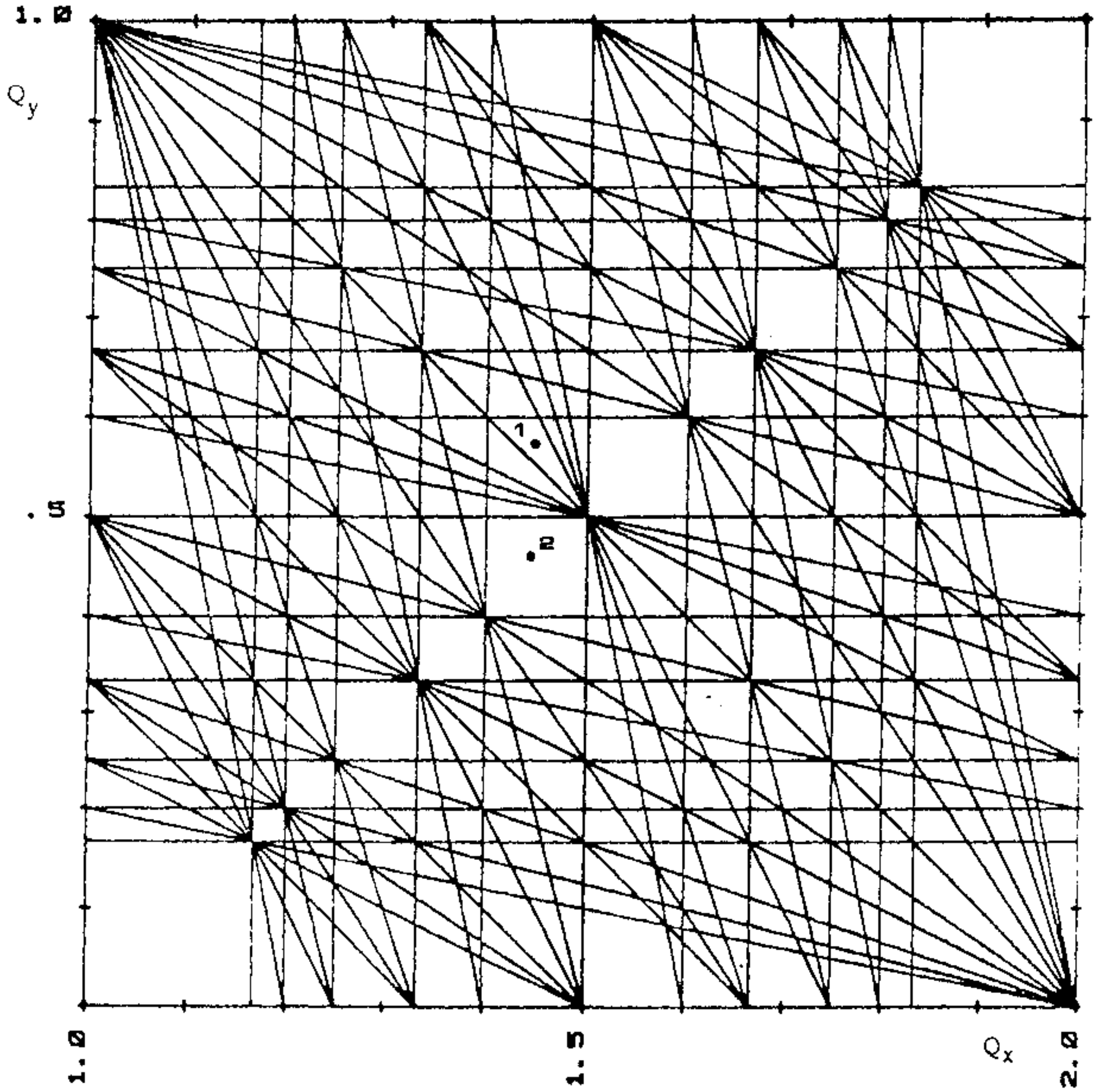

Fig. 1 - The resonance diagram. Betatron tunes for 1 period of the accumulator: 1) Old working point; 2) New working point.

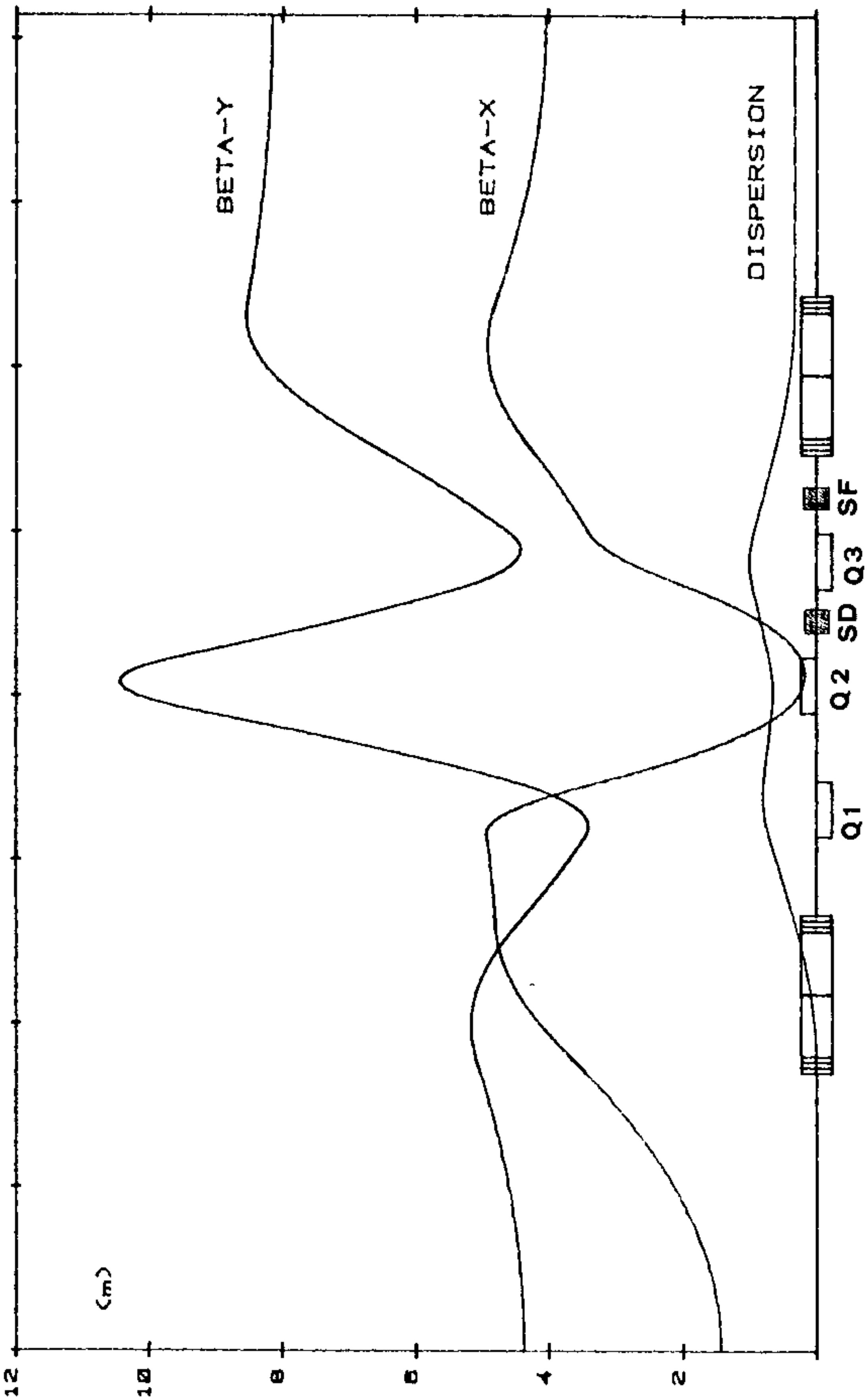

Fig. 2 - The optical functions for 1/4 of the ring.

TABLE I

Parameter list

Energy (GeV)	0.51
Circumference (m)	32.56
Straight section length (m)	3.50
Horizontal betatron wavenumber	2.89
Vertical betatron wavenumber	0.91
Dispersion at Septum Straight Section Center (SSSC) (m)	0.00
Horizontal β at SSSC (m)	1.44
Vertical β at SSSC (m)	4.37
Dispersion at Kicker Straight Section Center (KSSC) (m)	0.34
Horizontal β at KSSC (m)	4.03
Vertical β at KSSC (m)	8.16
Horizontal r.m.s beam size at SSSC (mm, no coupling)	0.64
Vertical r.m.s. beam size at SSSC (mm, full coupling)	0.79
Horizontal r.m.s. beam size at KSSC (mm, no coupling)	1.08
Vertical r.m.s. beam size at KSSC (mm, full coupling)	1.08
Maximum dispersion (m)	1.04
Maximum horizontal β (m)	4.88
Maximum vertical β (m)	10.40
Horizontal betatron damping time (msec)	21.42
Vertical betatron damping time (msec)	21.42
Synchrotron damping time (msec)	10.71
Momentum compaction	0.053
Natural emittance (mm.mrad)	0.285
R.m.s. energy spread (%, radiation only)	0.041
R.m.s. energy spread (%, Z/n=2Ω)	0.072
R.m.s. energy spread (%, Z/n=4Ω)	0.091
Horizontal chromaticity (sextupoles off)	-4.2
Vertical chromaticity (sextupoles off)	-3.8
R.F. frequency (MHz)	73.65
R.F. voltage (KV)	200
Harmonic number	8
Radiated energy per turn (KeV)	5.17
Synchrotron frequency (KHz)	49.12
R.F. energy acceptance (%)	2.38
R.m.s. bunch length (cm, radiation only)	2.19
R.m.s. bunch length (cm, Z/n = 2Ω)	3.85
R.m.s. bunch length (cm, Z/n = 4Ω)	4.85
Beam lifetime (minutes, P=10 ntorr, Z=8, Z/n=0)	40.7

TABLE II

magnetic structure

Quadrupoles			
number			12
magnetic length (cm)			34
bore radius (cm)			5
Quadrupole	strength (m^{-2})	gradient (T/m)	pole field (T)
Q1	3.85	6.54	.327
Q2	3.74	6.36	.318
Q3	3.57	6.07	.303
Sextupoles (for chromaticity C_x=C_y= +1)			
number			8
magnetic length (cm)			10
bore radius (cm)			5
Quadrupole	strength (m^{-3})	gradient(T/m^2)	pole field (T)
SD	72.39	123.06	.154
SF	68.09	115.75	.145

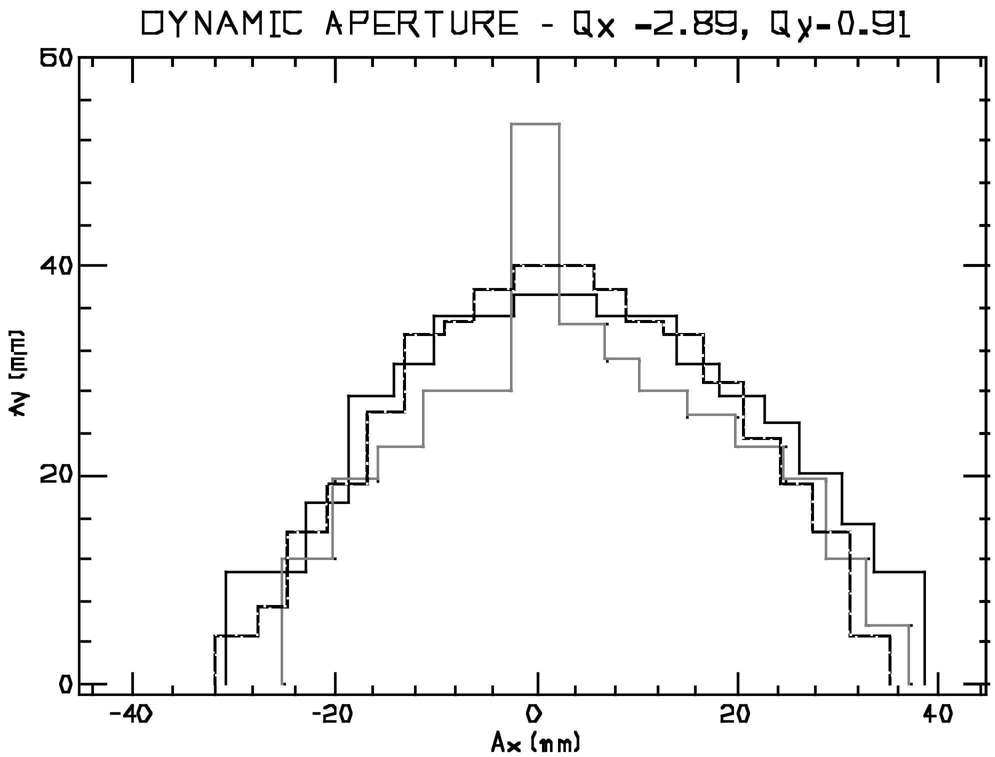

Fig. 3 - The dynamic aperture for the ideal machine:
______ Δp/p=0; · · · · · Δp/p= +1.5; - - - - Δp/p= -1.5

3. HIGH ORDER MULTIPOLES IN THE MAGNETIC FIELDS

For this new working point we looked for the dynamic aperture in both transverse planes as a function of magnetic multipole intensity. The analysis has been done using the computer code PATRICIA; we have introduced the same multipoles in all the magnets of the same kind (systematic errors), i.e. sextupoles, octupoles and decapoles in bendings and dodecapoles in quads. For sake of completeness, we considered also the octupole component in the quads, even if this does not contribute when the fourfold symmetry is respected. For each kind of multipole component we have considered four different values of the field variation, $\Delta B/B$, at 3 cm from the center: $\pm\ 2.5 \cdot 10^{-4}$, $\pm\ 5 \cdot 0^{-4}$. The results are shown in TABLE III, where the fraction (in per cent) of stable orbits is given as a function of error field intensity and particle energy.

TABLE III (a)

Dynamic aperture behaviour as a function of high order magnetic multipoles

octupole in quads

ΔB/B	$-5x10^{-4}$	$-2.5x10^{-4}$	$2.5x10^{-4}$	$5x10^{-4}$
	stable orbits (%) inside the required aperture [24x32 mm^2]			
ΔE/E= -1.5%	100	100	100	100
ΔE/E=0	100	100	100	100
ΔE/E= +1.5%	100	100	100	100

dodecapole in quads

ΔB/B	$-5x10^{-4}$	$-2.5x10^{-4}$	$2.5x10^{-4}$	$5x10^{-4}$
	stable orbits (%) inside the required aperture [24x32 mm^2]			
ΔE/E= -1.5%	100	100	100	100
ΔE/E=0	100	100	100	100
ΔE/E= +1.5%	87	100	100	100

TABLE III (b)

sextupole in bendings

$\Delta B/B$	$-5x10^{-4}$	$-2.5x10^{-4}$	$2.5x10^{-4}$	$5x10^{-4}$
	stable orbits (%) inside the required aperture [24x32 mm^2]			
$\Delta E/E$= -1.5%	100	100	100	100
$\Delta E/E$=0	100	100	100	100
$\Delta E/E$= +1.5%	100	100	100	100

octupole in bendings

$\Delta B/B$	$-5x10^{-4}$	$-2.5x10^{-4}$	$2.5x10^{-4}$	$5x10^{-4}$
	stable orbits (%) inside the required aperture [24x32 mm^2]			
$\Delta E/E$= -1.5%	84	98.3	100	95
$\Delta E/E$=0	96	100	100	98
$\Delta E/E$= +1.5%	100	100	100	100

decapole in bendings

$\Delta B/B$	$-5x10^{-4}$	$-2.5x10^{-4}$	$2.5x10^{-4}$	$5x10^{-4}$
	stable orbits (%) inside the required aperture [24x32 mm^2]			
$\Delta E/E$= -1.5%	90	100	100	98.3
$\Delta E/E$=0	100	100	100	100
$\Delta E/E$= +1.5%	100	100	100	100

The results set less stringent requirements on the design of the magnetic elements. It is clear that the octupole component in bendings is still the most dangerous one, but now we can accept a tolerance of 2.5x 10^{-4} at 3 cm from the center.

Decapoles and sextupoles in bendings should not exceed $\Delta B/B \approx 5 \cdot 10^{-4}$ at 3 cm from the center. A tolerance of $5 \cdot 10^{-4}$ in the dodecapoles is still acceptable in the quads.

REFERENCES

[1] S. Guiducci, M.R. Masullo, C. Milardi, M.A. Preger: "DAΦNE accumulator update 2" - DAΦNE Technical note I-4 (1/10/91).